3-F-61

INSTRUCTION MANUAL

CIMRON®

MODEL DMM-53

Invertron®

California Instruments
A Division Of Amstar Technical Products Company, Inc.

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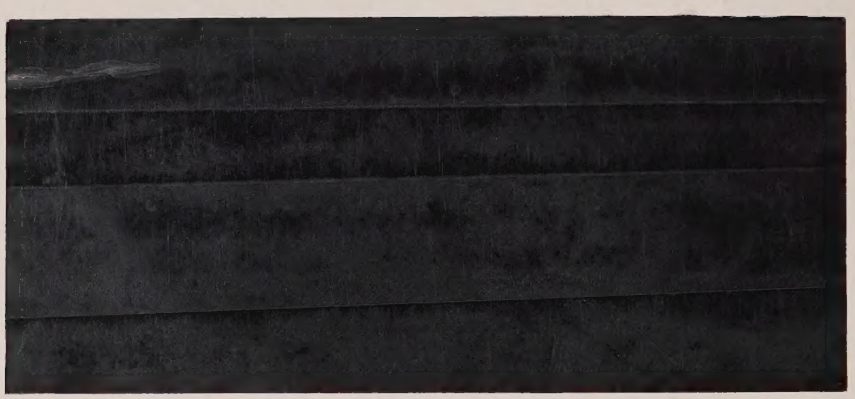

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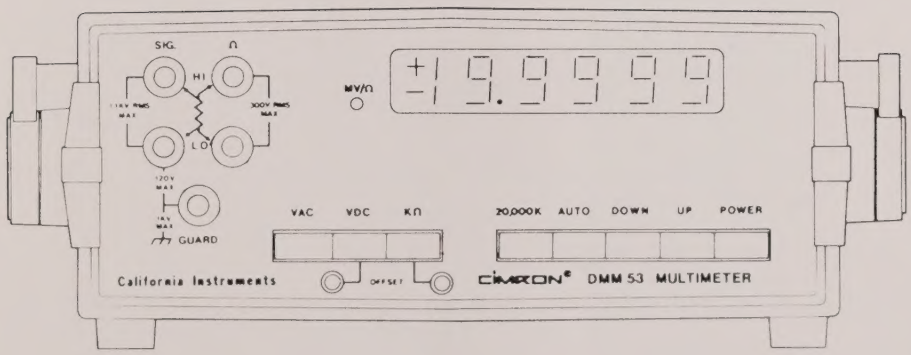

Original Issue
April 1978

Digitized by the Internet Archive
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May 18, 1978

DMM 53 MANUAL ERRATA

Page 1-3, Table 1-2:

Change the ACCURACY Specification for % of Range of the 2, 20, 200kΩ ranges from 0.00015 to 0.0015.

Page 1-3, Table 1-2:

Change the AC ACCURACY Specification for % of Range of the 200MV range from 0.015 to 0.15.

Page 5-3, Paragraph 5-25 (2):

The paragraph should read "Short the Ω HI, Ω LO and SIG LO terminals together and connect them to the SIG HI terminal."

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SECTION I
DESCRIPTION

1-1 INTRODUCTION

1-2 This manual contains physical and functional descriptions, principles of operation, operating and maintenance instructions (including schematic and component location diagrams) and lists of replacement parts for the CIMRON® Model DMM-53 Digital Multimeter manufactured by California Instruments Division of Aiken Industries. A photograph of the complete digital multimeter is shown on the frontispiece.

1-3 FUNCTION

1-4 The CIMRON® Model DMM-53 is basically a solid state, DC voltmeter, AC voltmeter and ohmmeter with autoranging. The use of dual slope analog-to-digital conversion and a 5-1/2 digit display result in extremely accurate readings of high resolution. AC volts are measured on an averaging basis but with RMS calibration.

1-5 PHYSICAL DESCRIPTION

1-6 The DMM-53 Digital Multimeter is intended to be used primarily as a bench instrument. However, an optional rack mount is available. Input terminals are provided for the input signal and for the ohmmeter reference output. A GUARD terminal is also provided. Three push buttons select VAC, VDC and KΩ operational modes. A group of four other push buttons select the 20,000KΩ range, autorange and manual up and down range control. A fifth push button in the second group is colored red and is a primary power control. The measurement display consists of five 1/2-inch high 7-segment display devices and a sixth display device showing + or — and 1 when appropriate. A single red LED is illuminated when the instrument is in the 200 millivolt range or in the 200 ohm range.

1-7 The instrument is housed in a plastic case equipped with a handle for carrying which also serves as a support to tilt the instrument upward at approximately 45 degrees from the horizontal when resting on the bench. The instrument measures 8-1/2 inches wide by 3-3/8 inches high by 9-1/4 inches overall (21.6 cm. by 8.6 cm. by 23.5 cm.) It weighs 4-1/2 pounds (2.04 kg) with the optional print board installed.

1-8 When the PRINT BOARD (option 02) is installed, a rear panel connector is provided with appropriate connections to the internal circuits so that the instrument may drive the input to a computer, hard copy printer or other peripheral device. The output data is in binary coded decimal (BCD) form.

1-9 OPTIONS

1-10 A number of options are available for the DMM-53 Digital Multimeter and consist of the print board, measurement cable set and rack mount. These are listed in Table 1-1.

1-11 SPECIFICATIONS AND PERFORMANCE DATA

1-12 Specifications and performance data for the Model DMM-53 Digital Multimeter are listed in Table 1-2. Units are factory tested to these specifications in accordance with California Instruments Division test procedures as detailed in Section V of this manual.

Table 1-1. Optional Equipment List.

OPTION NUMBER	OPTION
01	Cable Set
02	Print Board
03	Rack Mount

Table 1-2. Specifications, DMM-53 Multimeter.

GENERAL

MAXIMUM COMMON MODE VOLTAGE:	700V RMS, 1000V DC.
READING RATE:	Two per Second.
DISPLAY:	Seven-Segment, 0.5 Inch, LED Digits.
WARM UP:	One hour to Full Specification.
OVERLOAD INDICATION:	Flashing Display.
OPERATING TEMPERATURE:	0°C to 55°C.
OPERATING HUMIDITY:	0 to 80% at 23°C.
SIZE:	8-1/2 in. Wide, 3-5/8 in. High, 9-1/4 in. Overall (Incl. Handle). (21.6 cm x 8.6 cm x 23.5 cm).
WEIGHT:	4-1/2 Pounds (2.04 Kilograms) With Print Board Installed.
POWER REQUIREMENTS:	115/220V AC ±10%, 48 to 420 Hz. 10 Watts at 115V, 60 Hz.

RANGE CHARACTERISTICS

FUNCTION	RANGE	INPUT		FAULT VOLTAGE	SELECTION
		SENSITIVITY	RESISTANCE/CURRENT		
DC	200MV	1 Microvolt	1000 Megohms	1200V Peak AC or 1200V DC for 10 Seconds. ↓ 1200V DC or Peak AC. ↓	Auto or Manual ↓ ↓ ↓

Table 1-2. (Continued).

ADDITIONAL CHARACTERISTICS

DC VOLTS	Common Mode Rejection Ratio:	120 dB at 50 Hz and 60 Hz (1KΩ Unbalance).
	Normal Mode Rejection Ratio:	60 dB at 50 Hz and 60 Hz.
OHMS	Configuration:	4-Terminal, front panel zero.
	Open Circuit Voltage:	5VDC, all ranges except 20000KΩ. 26VDC on 20000KΩ range (manual only).

DC ACCURACY

	ACCURACY				TEMPERATURE COEFFICIENT	RESPONSE TIME
	% Of Input + % Of Range				(% Of Input + % Of Range)/°C	
	24 Hrs.	6 Mos.	1 Yr.	All Periods		
RANGE	23°C	18°C To 28°C			0°C To 18°C And 28°C To 50°C	Within Range
DC						
20V	0.003	0.007	0.01	0.0015	(0.0007 + 0.0002)	1 Second to 0.005% of Range.
2V, 200V, 1200V	0.004	0.009	0.013	0.0015	(0.0008 + 0.0005	
200MV	0.004	0.01	0.014	0.003	(0.001 + 0.0005)	
OHMS		Ohms Zero Allowed				
2, 20, 200KΩ		0.01	0.015	0.00015	(0.003 + 0.00025)	1 Second + (0.1 Second/Megohm) to 0.01% of Range.
200Ω		0.01	0.015	0.0025	(0.005 + 0.0025)	
2000KΩ		0.03	0.045	0.0015	(0.005 + 0.0005)	
20000KΩ		0.1	0.15	0.0015	(0.005 + 0.0005)	

AC ACCURACY

	ACCURACY			TEMPERATURE COEFFICIENT	
	6 Months (18°C To 28°C)			0°C To 18°C And 28°C To 50°C	
	% Of Input + % Of Range			(% Of Input + % Of Range)/°C	
RANGE →	20V, 1000V	2V, 200V	200MV	2V, 20V, 200V, 1000V	200MV
FREQUENCY					
40 Hz to 100 Hz	0.1 + 0.025	0.12 + 0.05	0.015 + 0.3	0.008 + 0.001	0.008 + 0.01
100 Hz to 5 KHz	0.1 + 0.01	0.1 + 0.03	0.12 + 0.2	↓	↓
5 KHz to 20 KHz	0.25 + 0.025	0.25 + 0.05	0.4 + 0.25		
20 KHz to 100 KHz	1.0 + 0.05	1.0 + 0.125	1.0 + 0.75		

ONE YEAR ACCURACY (18°C to 28°C):
Use 6 month specification with % of input multiplied by 1.2.

RESPONSE TIME: 3-Seconds to 0.025% of Range.

ISOLATED BCD OUTPUT (Option 2)	DATA:	Digits, Polarity, Range.
	FORMAT:	BDC, Positive True, Parallel.
	DRIVE:	Two TTL Loads (Sink 3.2 ma.).
	CONTROLS:	Data Gate, $\overline{\text{HOLD}}$/READ.

SECTION II
INSTALLATION

2-1 GENERAL

2-2 This section of the manual provides instructions for unpacking, inspection for in-shipment damage, pre-operational tests and mechanical installation of the DMM-53 Digital Multimeter.

WARNING

This equipment is powered by potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. Do not touch electronic circuits when power is applied. Avoid contact with all input power connections. Verify that power supply voltages are discharged to safe levels after power turn-off before touching circuitry.

2-3 INITIAL INSPECTION IN CONTAINER

2-4 A visual inspection of the shipping container should be accomplished prior to acceptance from the carrier. If extensive damage to the shipping container is evident, a description of the damage should be noted on the carrier's receipt and signed by the carrier's agent.

2-5 UNPACKING

2-6 Each Model DMM-53 Digital Multimeter is shipped in a cardboard container with protective inner packing, according to best commercial standards, and can be unpacked using standard procedures. Do not destroy the packing containers until the unit has been inspected for possible damage in shipment.

2-7 INITIAL INSPECTION

2-8 Visually inspect the Digital Multimeter for obvious mechanical damage, dents, broken controls, front and rear terminals and front panel breakage. If any damage is evident, notify the carrier. Do not return an instrument to the factory for repair without prior approval.

2-9 POWER REQUIREMENTS

2-10 The CIMRON® Model DMM-53 Digital Multimeter may be powered from a 48 to 420 Hz power line. The unit is normally set for operation from 115V RMS ±10%. Voltages above this limit may damage the instrument and voltages below this limit will result in below standard performance. The unit may also be operated from 220V RMS ±10% by resetting the power selector switch, A1S2, located adjacent to the power transformer, A1T1, on the main circuit board. The Multimeter requires power of approximately 10 watts from the AC line.

2-11 FUSE PROTECTION

2-12 The Digital Multimeter is protected by a single 1/8-ampere slo-blo fuse retained in a twist-out holder mounted in the rear panel of the instrument.

2-13 POWER INPUT WIRING

2-14 The Digital Multimeter is supplied with a conventional three-pronged input power plug on the end of a six-foot cable and is used with 115 volt AC lines with a capacity of 1 ampere or greater. To operate the unit from a 220 volt source, it may be necessary to remove the plug and replace it with one compatible with the existing 220 volt receptacle.

2-15 PRELIMINARY CHECKS AND ADJUSTMENTS

2-16 Each Model DMM-53 Digital Multimeter is carefully inspected and adjusted at the factory and should not normally require adjustment at time of installation. However, the following checks should be performed to verify functional operation. A list of required test equipment will be found in Table 5-1.

A. Connect the unit to the power source, turn power on by depressing the POWER push button and allow one hour for warm up and stabilization.

B. Short the input leads, select the DC function by depressing the VDC push button, place the unit in manual operation by releasing the AUTO switch, if depressed, and select the 2 volt range by depressing the DOWN or UP push button as necessary until the five digits are to the right of the decimal point. If the display does not read .00000, select the 200 millivolt range by again depressing the DOWN push button until the MV/ΩLED is illuminated. Adjust the VDC offset for a reading of ±00.000.

C. Using a Fluke Model 335D, or equivalent DC Standard, apply +1.00000 volts to the input of the instrument. Display should indicate +1.00000, ±12 digits.

D. Select the AC function by depressing the VAC button and then select the 20 volt range. Using a Hewlett Packard Model 745, or equivalent AC Calibrator, apply 10.0000 volts RMS at 300 Hz to the input terminals. The display should read 10.0000, ±120 digits.

E. Select the OHMS function by depressing the KΩ

button and select the 20K Ω range. Connect a 10K ohm ±0.0005% resistor to the input, as shown on the diagram at the input terminals. Display should read 10.0000, ±13 digits.

2-17 Failure of the unit to operate within the limits set forth above indicates the need for adjustment of the unit in accordance with calibration procedures detailed in Section V of this manual.

2-18 MECHANICAL INSTALLATION

2-19 The CIMRON ® Model DMM-53 Digital Multimeter is designed for bench or rack mounting. Bench mounting presents no installation problems. Rack mounting requires that adequate clearance be provided between the Model DMM-53 and other equipment and that a free flow of air be available to maintain the temperature of the surrounding air at or below +55°C. Heat will have an adverse effect on any item of electronic equipment and useful life will be prolonged if lower temperatures are maintained. A dimensioned outline drawing of the DMM-53 Digital Multimeter is shown in Figure 2-1.

2-20 SIGNAL CONNECTIONS

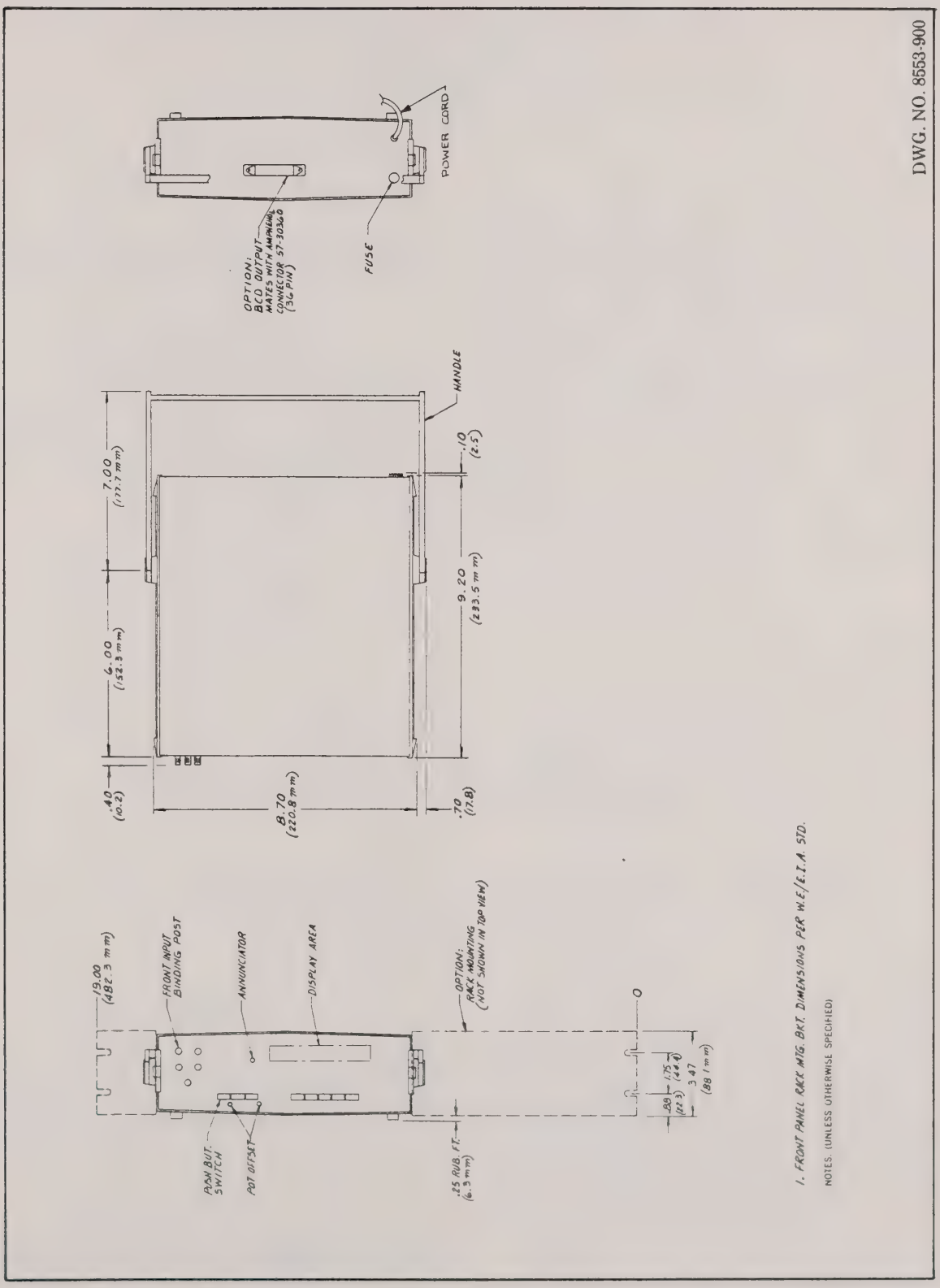
2-21 Five terminals are provided on the front panel for connection to external voltages and resistances to be measured. For all AC and DC measurements, the input is connected to the SIG HI and SIG LO terminals. For all normal voltage measurements, the GUARD terminal should be connected to SIG LO. When measuring high resistances, where the resistance of the connecting leads is of little importance, the BLACK terminals may be connected together and the RED terminals may be connected together with straps or short leads. The test leads are then connected to the RED and BLACK SIG terminals. When low resistances are to be measured, the four-wire system should be used. Separate leads from the RED terminals are connected to one terminal of the unknown resistance. Separate leads from the BLACK terminals are then connected to the other terminal of the unknown resistance. Since the test current is not flowing in the leads connecting the resistors to the input of the voltmeter section of the instrument, resistance of those leads will have no effect on the reading. Also, since current flowing between the Ω terminals is constant, irrespective of total circuit resistance, the voltage drop across the resistor will be a true measure of its resistance which will be measured by the voltmeter section of the instrument.

2-22 PRINT BOARD CONNECTIONS

2-23 Table 2-1 lists the connections to the rear panel print board connector, A3J7, which will be installed only if the Print Board (option 02) is installed. The range outputs are functional at all times. DATA GATE goes high at the end of the measurement sequence and POLARITY will go high, in the DC mode, when the input is of positive polarity. It will be low when the DC input is of negative polarity and will also be low in the AC and KΩ modes. The data output levels may be held at the end of a measurement sequence if $\overline{\text{HOLD}}$/READ is immediately pulled low after DATA GATE goes high. First measurement accuracy is guaranteed at the output of the PRINT BOARD by an internal circuit which delays the measurement output for two seconds after an automatic or manual range change. The output devices of the PRINT BOARD are low-power, Shottky with levels from zero to 1.4 volts DC for a logic zero and 2.4 to 5.0 volts DC for a logic 1.

Table 2-1. Print Board Output Connections.

PIN NO.	SIGNAL	PIN NO.	SIGNAL
1	COMMON	19	RANGE (A)
6	1 ⎫	20	RANGE (B)
4	2 ⎬ 10^0	21	RANGE (C)
3	4 ⎭	22	+ POLARITY
5	8	26	1 ⎫
7	N/C	24	2 ⎬ 10^3
8	N/C	23	4 ⎭
12	1 ⎫	25	8
10	2 ⎬ 10^1	27	$\overline{\text{HOLD}}$/READ
9	4 ⎭	28	N/C
11	8	29	COMMON
13	10^5	30	COMMON
14	DATA GATE	34	1 ⎫
18	1 ⎫	32	2 ⎬ 10^4
16	2 ⎬ 10^2	31	4 ⎭
15	4 ⎭	33	8
17	8		



DWG. NO. 8553-900

Figure 2-1. Outline Dimensions, Model DMM-53 Multimeter.

SECTION III
OPERATION

3-1 GENERAL

3-2 This section of the manual provides instructions for the use and operation of each control and front panel adjustment and connections to external circuits.

3-3 FRONT PANEL OPERATING CONTROLS AND INDICATORS

3-4 The front panel operating controls and indicators are shown in Figure 3-1.

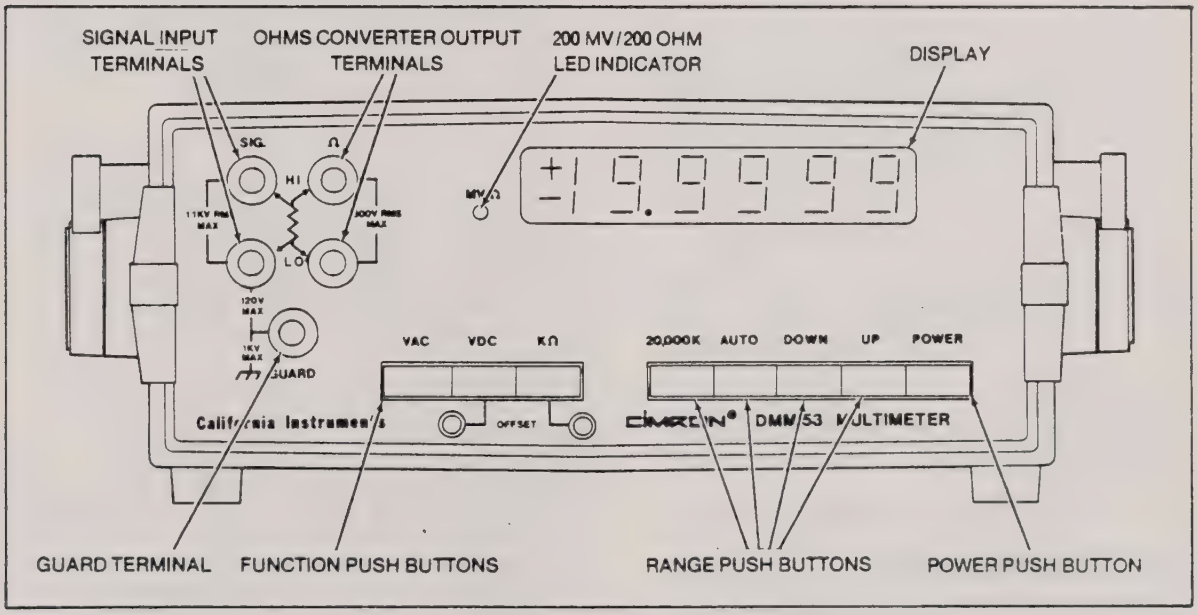


Figure 3-1. Front Panel Operating Controls and Indicators.

3-5 INITIAL ADJUSTMENTS AND CONTROL SETTINGS

3-6 The CIMRON® Model DMM-53 Digital Multimeter has been adjusted at the factory and should not require special adjustments prior to operation except to set the front panel zero controls. These adjustments are covered in later paragraphs of this section.

3-7 START UP PROCEDURE

3-8 Connect the instrument to a source of 115V AC power (220V AC if switch A1S2 is set at 230V). Push the red POWER switch and note that the display is illuminated. Wait one hour for the instrument to stabilize.

3-9 AUTO/MANUAL RANGE SELECTION

3-10 In any of the modes of operation, except 20,000KΩ, autoranging or manual ranging may be selected. To select autorange, depress the AUTO push button. To return the instrument to manual ranging, again, depress and then release the AUTO push button. Manual range selection is accomplished by depressing either the UP or DOWN push button. With the instrument in the 200 miliivolts (or ohms) range, the decimal point will be located to the right of the third most significant digit of the display. At the same time, the MV/Ω indicator will be illuminated to indicate that the instrument is operating in the lowest range. When the UP push button is depressed and released, the decimal point will move to the right of the most significant digit (which may or may not be visible) and the MV/Ω indicator will be extinguished. Thereafter, each time the UP push button is depressed, the decimal point will move one digit to the right until the instrument is in the highest range (limited to 2,000KΩ in the KΩ function). Depressing and releasing the DOWN push button moves the decimal point in a manner just opposite to that described for the UP push button.

3-11 When the unit is operating in the autorange mode, and the input voltage, or resistance, is greater than that

for which the instrument was designed (overrange), the display will blink at a rate between 1 and 2 times-per-second. Also, in autorange, the instrument will down range until the displayed reading is 9999. or more or until it has reached the lowest range. In the manual range selection mode, the display will blink whenever the input voltage, or resistance, being measured is greater than that for the selected range.

CAUTION

If the display continues to blink, immediately disconnect the applied input signal. Overvoltage can result in permanent damage to the instrument.

3-12 VOLTAGE MEASUREMENTS

3-13 Select automatic or manual range control as desired. Depress the VDC push button. Connect the GUARD terminal to the SIG LO terminal.

3-14 Connect two leads from the SIG HI (RED) and SIG LO (BLACK) terminals to the circuit to be measured. Allow the instrument to settle if in autorange, and read the measured voltage and its polarity directly from the display. If in the manual range control mode, it may be necessary to up-range or down-range the instrument to bring the range in concert with the measured voltage.

3-15 AC VOLTAGE MEASUREMENTS

3-16 Select automatic or manual range control as desired. Depress the VAC push button. Connect the GUARD terminal to the SIG LO terminal.

3-17 Connect two leads from the SIG HI (RED) and the SIG LO (BLACK) terminals to the circuit to be measured. Allow the instrument to settle if in autorange and read the measured voltage directly from the display.

3-18 RESISTANCE MEASUREMENTS

3-19 TWO-WIRE SYSTEM

3-20 Connect the two RED terminals (SIG HI and REF HI) together with a strap or short length of wire. Connect the BLACK terminals (SIG LO and REF LO) together with a strap or short length of wire.

NOTE

The front panel KΩ offset adjustment has a range of less than 200 milliohms. If the lead resistance exceeds 200 milliohms in a two-wire KΩ measurement, it may not be possible to obtain a display zero on the two lowest resistance ranges.

CAUTION

The GUARD terminal should be terminated for reliable measurements. It may be connected to the BLACK REF LO terminal or, in a high noise environment, connected to a shield around the unknown resistance. Any AC voltage that is externally generated between the GUARD terminal and the BLACK terminal may cause instability and/or error in the display reading.

3-21 Select autorange or manual range control as desired. Depress the KΩ push button and connect two leads from the RED and BLACK terminals to the resistance to be measured. Allow the instrument to settle, if in autorange, and read the resistance directly from the display. If in the manual range control mode, it may be necessary to select a different range to bring the range in concert with the measured resistance.

3-22 FOUR-WIRE SYSTEM

3-23 An optional set of leads are available for the four-wire resistance measuring system as shown in Section I. In the four-wire system, constant current from the OHMS Converter is applied to the resistance to be measured through two independent leads. Thus, only the voltage drop across the resistor is measured rather than that of the resistor and the leads connecting it to the instrument. This is of particular importance where the resistance under measurement is on the order of a few ohms or less.

NOTE

To obtain a reading of zero in the 200Ω range, a four-wire short must be used. A modified four-wire short may also be used with satisfactory results. To obtain a modified four-wire short, stack the ohmmeter leads, as shown in Figure 3-2. The KΩ offset adjust may now be used to obtain a reading of zero.

3-24 HANDLE ADJUSTMENT

3-25 The handle of the DMM-53, in addition to being a carrying handle, is also an adjustable support for tilting the instrument to improve the viewing angle when the unit is setting on the bench. To change the position of the handle, pull outward on both of the handle pivots. The handle will move outward about 3/16 of an inch. While holding the handle in this position, rotate it to the position desired. The stops on the handle pivots allow the handle to be adjusted in 30 degree increments over 360 degrees.

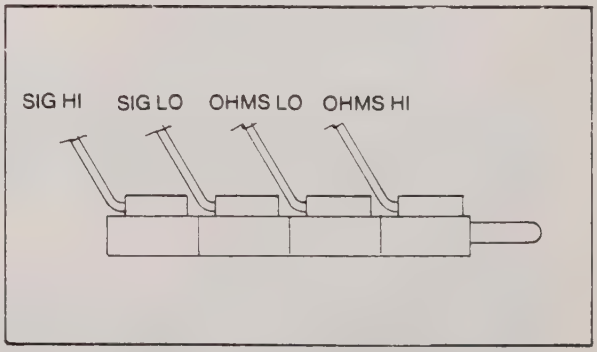


Figure 3-2. Modified Four-Wire Short.

SECTION IV
PRINCIPLES OF OPERATION

4-1 GENERAL

4-2 The CIMRON(R) DMM-53 Digital Multimeter is a precision device for measuring DC and AC voltages and resistance with high accuracy and resolution. It is, basically, a DC instrument with an AC Converter that provides a rectified and filtered output for measurement by the DC circuits. To measure resistance, it pumps a precise current through the unknown resistance, then measures the DC voltage developed across that resistance.

4-3 The DMM-53 employs dual slope analog-to-digital conversion to convert the DC analog input voltage to a 5-1/2 digit display. This system of integration is noted for its accuracy, speed of measurement and inherent rejection of line frequency related noise.

4-4 The instrument operates in serial states of 100 or 200 milliseconds each. Refer to Timing Diagram, Figure 4-1. During the first state (T0) the auto zero function compensates for initial offsets and drift in the analog circuits. During the second state (TX) the unknown voltage is integrated. The level of the integrator output at the end of TX is precisely proportional to the input voltage. During the third state (TR) a precision reference voltage of opposite polarity is integrated driving the integrator output back to zero. The time required to drive the integrator output to zero is directly proportional to the applied input voltage. It is precisely measured by counting a crystal controlled clock, accomplishing the digital-to-analog conversion. The clock count is presented on a 5-1/2 digit LED display. If the input is beyond the full scale limit of the selected range, a fourth state, TR0, will be entered. Integration of the reference continues until zero is reached. However, the display blinks and shows only the maximum reading for the selected range.

4-5 The ranging system may be manually or automatically controlled. When manually controlled, the operator selects a range that will display the measured input with the degree of resolution desired. If the input is beyond the full scale limit of the selected range, the display will begin to blink approximately twice per second, indicating that a higher range should be selected. When operating in the autorange mode, the system selects the range which will display the measured input with the greatest resolution. Whenever the input is beyond the full scale limit of the instrument, the display will blink until the input is removed.

4-6 FUNCTIONAL DESCRIPTION

4-7 BASIC MEASUREMENT SYSTEM

4-8 A simplified block diagram of the DC measuring circuits of the DMM-53 Multimeter is shown in Figure 4-2. The Timing Diagram, Figure 4-1, shows the several timing signals basic to the operation of the instrument, the operational states and the three operational periods. The sequence of measurement is:

A. Auto Zero (T0).
B. Integrate the unknown (TX).
C. Integrate the reference while counting the clock (TR).
D. Display the clock count.

4-9 If the instrument is in autorange, steps A, B and C will be repeated until the clock count is within the autorange limits of 10,000 to 199,999 counts.

4-10 During the T0 period, the autozero function compensates for all offsets and drift in the input amplifier, integrator and comparator. During the TX period, the amplified input voltage is integrated. The level of the output of the integrator at the end of TX is a linear function of the input voltage. The polarity of the integrator output will be opposite that of the input voltage polarity. At the end of TX, a polarity detector stores the polarity of the integrator. A precision reference voltage, from the reference inverter, is then applied to the input of the integrator. Its polarity will be that required to drive the output of the integrator back towards zero. Whereas the slope of the integrator during TX is proportional to the level of the input voltage, the reference integration will produce a constant slope as shown in the Timing Diagram, Figure 4-1. Therefore, the time to integrate the reference to zero is a precise measurement of the unknown input.

4-11 At zero detection, the flow of pulses from the crystal controlled oscillator to the counter is interrupted. Simultaneously, the output of the counters is multiplexed to the seven-segment display devices. During TR, the logic circuits count the crystal controlled clock pulses with the number of counts being an accurate measurement of the input voltage. A number of switching circuits operate at the end of T0 and at the end of TX. To prevent measurement errors due to the switching transients and to allow for the slewing time of the operational amplifiers, the logic circuits disconnect the integrator input for 0.1 milliseconds following T0 and TR. These are the TB1 and TB2 periods shown in Figure 4-1. A transient could occur at the end of the TB2 period when the integrator input is connected to the reference inverter. To prevent such a transient from signalling a false zero crossing, the zero detect system is disabled and the start of the clock count is delayed for a period equal to 100 counts (100 microseconds). Since integration is in process during this 100 count period, compensation is provided so that errors do not occur. The operation of the compensation circuit is covered under the detailed circuit descriptions of later paragraphs.

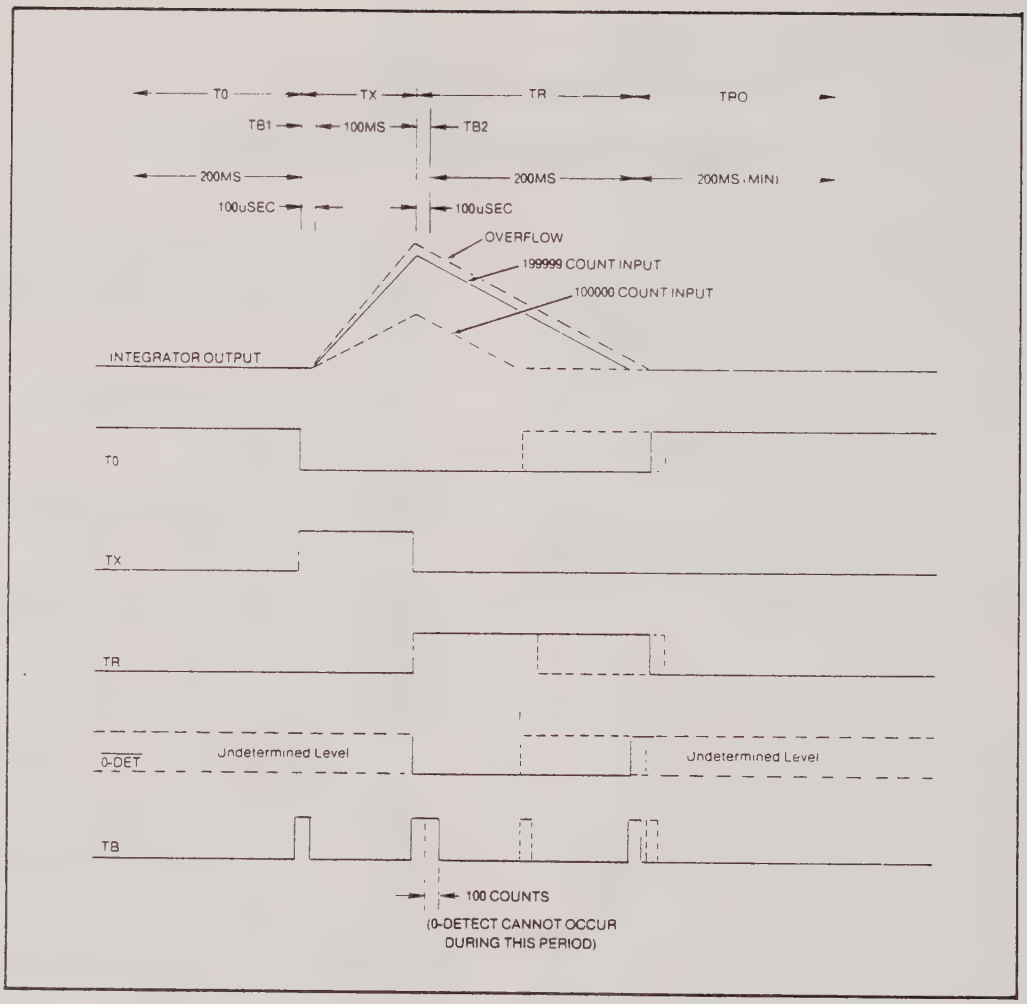


Figure 4-1. Timing Diagram.

4-12 At zero detection, the flow of pulses from the crystal controlled oscillator, which have been accumulating in a counter within A2U3, is interrupted. Simultaneously, the output of the counter is strobed and stored in latches. The latched outputs, in turn, are connected to BCD-to-seven segment decoder-drivers that drive the seven-segment displays. A new sequence is initiated immediately. Therefore, if the input voltage is changing, the operator will see a new value displayed each time the measurement sequence is completed.

4-13 RANGING SYSTEM

4-14 Refer to Figure 4-3 which is a block diagram of the basic system with the autorange function and control functions added. The ranging system operates in both manual and automatic modes. When operating in the manual mode, the operator selects a range where the input will not exceed the full scale limit and the desired resolution may be obtained. Whenever the input results in a count exceeding 199999, the display will blink twice per second. The operator must then manually select higher ranges until a valid display is obtained.

4-15 When operating in the autorange mode, the instrument will automatically advance to the next range if the count at the end of the measurement sequence exceeds 199999. Range advances will continue until a count of 199999, or less, has been obtained or the system has advanced to the highest range. If the system has advanced to the highest range and the count still exceeds 199999, the display will blink twice-per-second. Also, while in the autorange mode, if the count at the end of the measurement sequence is less than 10,000, the system will select the next lowest range where it will repeat the measurement sequence. The system will continue to select a lower range until the count is 9,999, or greater, or the lowest range is reached. The measurement will then be displayed.

4-16 There are five basic ranges or range states, R0 through R4 that are used in all modes—DC, AC and KΩ

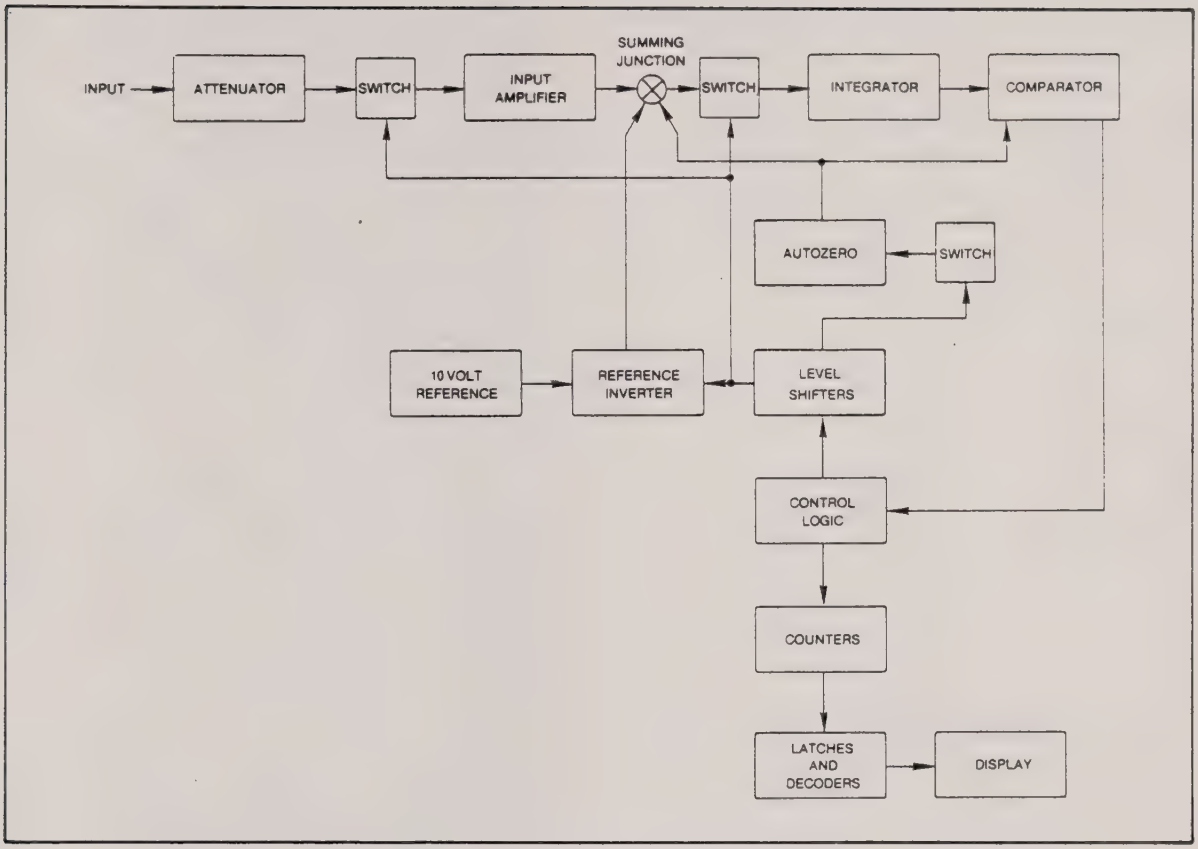


Figure 4-2. Block Diagram, Measuring Circuits.

When in the 20,000KΩ mode, the system is locked in range R5. While in the 20,000KΩ mode, autoranging and manual ranging are inhibited to prevent accidentally entering another range with high open circuit voltage (26V).

4-17 By controlling the input attenuation and the input amplifier gain, the ranging system insures that the output of the input amplifier remains within the 0-20 volt or 0-2 volt range during measurements. This is accomplished through a logic system that accepts range state and mode of operation inputs and then closes relays in the input circuit and amplifier feedback loop. These relays insert an attenuator in the input circuit and select appropriate resistance values for the amplifier feedback loop to adjust amplifier gain. In addition to these relays, those of the AC Converter and the OHMS Converter are also operated by the ranging system.

4-18 AC CONVERTER

4-19 The AC Converter rectifies the AC input signal and filters the resulting DC voltage which is then applied to the DC measuring circuits. The DC voltage at the output of the AC Converter is representative of the RMS value of a sine wave input voltage.

4-20 All signals from the SIG HI input pass through a set of contacts on the VAC switch to the DC input attenuator. When the VAC switch is depressed, the path is interrupted and the signal is applied directly to the input of the AC Converter. The output of the AC Converter, which is a DC voltage, is then applied to the input attenuator.

4-21 OHMS CONVERTER

4-22 The OHMS Converter is a precision constant current source. The current which it produces is pumped through the external unknown resistance. The voltage which is developed across that resistance is then applied to the DC measuring circuits of the DMM-53. The current value is different for the several resistance ranges and is determined by precision resistor networks which are selected by relays in the OHMS Converter which are energized in the order shown in Table 4-1. When the unknown resistance to be measured is within the range selected, the voltage developed across that resistance will be in the range of 0 to 2 volts or 0 to 20 volts in the 20,000KΩ range.

4-23 ISOLATION

4-24 The analog and digital circuits are isolated from the

Table 4-1. Relay Closures as a Function of Range.

FUNCTION	RANGE	RELAY CLOSURE
20,000 KΩ	R5	All Open
2,000 KΩ	R4	K3
200 KΩ	R3	K3, K5
20 KΩ	R2	K3, K6
2 KΩ	R1	K3, K7
200Ω	R0	K3, K4, K7
1200 VDC	R4	K2
200 VDC	R3	K2, K3
20 VDC	R2	
2 VDC	R1	K3
200 MVDC	R0	K3, K4
1000 VAC	R4	K1
200 VAC	R3	K1, K3
20 VAC	R2	
2 VAC	R1	K3
200 MVAC	R0	K3, K4

117/230V AC line. The potential difference between the power input ground and the input terminals is limited to 1000V peak.

4-25 PRINT BOARD OPTION

4-26 The single item of optional equipment for the DMM-53 is a plug-in circuit board that parallels the display driving circuits. It provides a BCD coded output for computer input, driving signals for a hard copy printer or remote display. Section II, Installation, provides information for making the external connection to the optional print board.

4-27 DETAILED CIRCUIT DESCRIPTION

4-28 GENERAL

4-29 The detailed circuit descriptions of the following paragraphs are referenced to the schematic diagrams of Section VI and simplified circuit diagrams of this section. The analog circuitry of the DMM-53 utilizes operational amplifiers and field effect transistors. "Understanding IC Operational Amplifiers," written by Roger Melan and Harry Garlan and published by Howard W. Sams and Company is an excellent introduction to operational amplifiers. Operational amplifiers, when operated open loop, exhibit amplification factors in the order of several hundred thousand. When the gain is limited to one hundred, or less, by external feedback, operational amplifiers are quite stable over a wide range of environmental conditions. They are, therefore, excellent devices for use in a precision voltage measuring system such as the DMM-53 Digital Multimeter.

4-30 Field effect transistors used in the DMM-53 serve as series switches. They require extremely low driving power and provide a series resistance of several thousand megohms when open and approximately two-hundred ohms when closed.

4-31 The digital logic devices utilized in the DMM-53 are of the low powered Schottky TTL family and are basically of the NAND type. A logic "0", or low state, is defined as between zero volts and +0.4 volts. A logic "1", or high state, is defined as between +2.4 volts and +5 volts. Where more than one device is contained within a single package, the device is identified with the output terminal, e.g., A1U21-6, or, in the case of multiple-package FET's, with the gate terminal number.

4-32 POWER SUPPLIES

4-33 There are a number of power sources and voltage regulators in the instrument that provide the several different voltages required. The circuits of the several power supplies are shown in the schematic diagram of Figure 6-2. All power is derived from the line through a single power transformer, A1T1, which is mounted directly on the printed circiut board, A1. The input to this transformer is protected by a fuse, F1, located at the rear of the chassis. Power input may be 115V AC or 220V AC as determined by the position of switch A1S2 located on the circuit board adjacent to the power transformer. Transformer A1T1 has electrostatic shields to minimize capacitive coupling between the primary and secondary windings and the effect of such coupling on the common mode characteristics of the instrument.

4-34 DIGITAL SUPPLIES

4-35 The AC voltage appearing across one secondary of A1T1 is rectified and filtered and applied to an integrated circuit voltage regulator, A1U4. The output of A1U4 is approximately +5 volts and is used to power the digital logic circuits. Two diodes, A1CR5 and A1CR6, connected across the same secondary winding of A1T1, produce unfiltered +9 volts which is used as the power source for the seven-segment LED display devices.

4-36 ANALOG SUPPLIES

4-37 Bridge rectifier A1CR9 rectifies the AC voltage appearing across a section of one secondary winding of A1T1 to produce +24 volts and −24 volts. These levels are regulated to +18 volts and −18 volts by integrated circuit voltage regulators A1U7 and A1U8. These outputs are used to power the operational amplifiers of the analog circuitry. The AC appearing across the full winding of one of the secondaries of A1T1 is rectified by A1CR8 and then filtered to produce +27 volts and −27 volts which is also used to power some of the operational amplifiers of the analog circuitry.

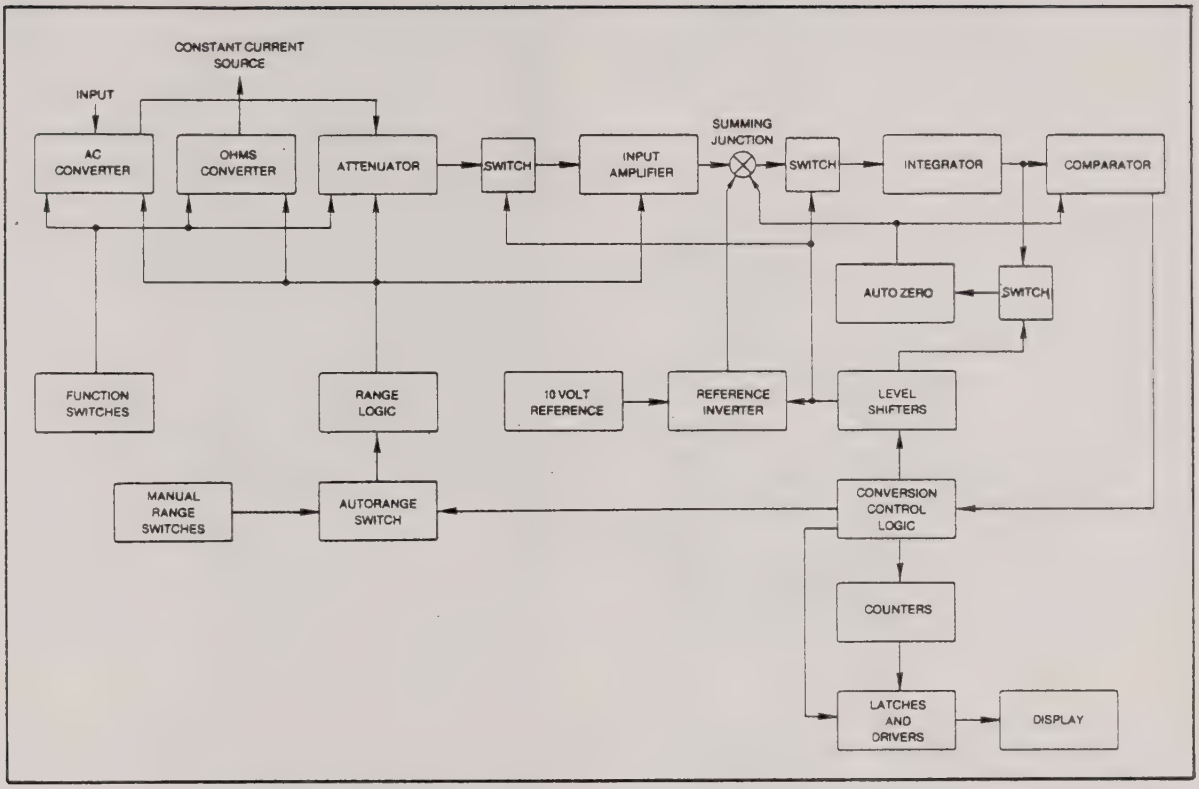


Figure 4-3. Block Diagram, Measuring Circuits and Range Control.

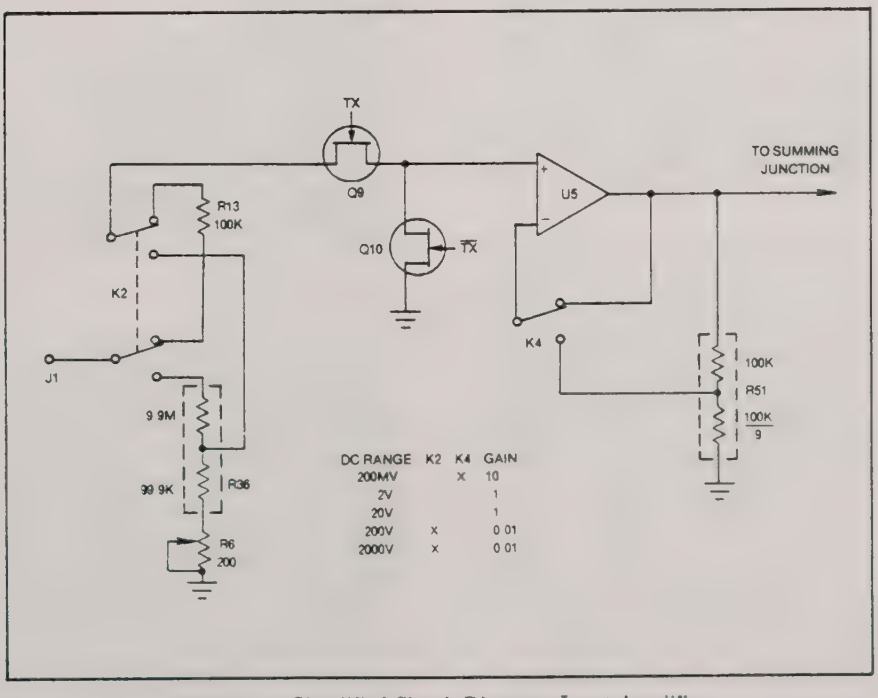


Figure 4-4. Simplified Circuit Diagram, Input Amplifier.

4-38 10 VOLT REFERENCE

4-39 An accurate and stable reference voltage is required for the integrator and as a reference current source for the OHMS Converter. This 10 volt reference is obtained at the output of A1U2, an integrated circuit voltage regulator, which is supplied from the +18 volt bus.

4-40 INPUT AMPLIFIER

4-41 A simplified schematic diagram of the input amplifier circuit is shown in Figure 4-4. The input amplifier presents a very high impedance to the input signal and isolates the input from the integrator. Relay A1K2 and A1R36 form an input attenuator for the two highest ranges as shown in the table within Figure 4-4. The input signal is routed through A1K2 and through FET switch A1Q9 to the non-inverting input of input amplifier, A1U5. A1Q9 will be turned on during TX (reference Timing Diagram, Figure 4-1) and will be turned off during T0 and TR. Note that TX is the period in which the unknown input is integrated. Selection of a range, appropriate to the input voltage to be measured, sets the attenuator and the gain of the input amplifier. The gain of the input amplifier is controlled by relay A1K4 which introduces a second resistor network between the output of the amplifier and its inverting input when the instrument is in the 200MV ranges.

4-42 Refer to Figure 6-2. Observe the complete schematic of the input amplifier at the upper center of the diagram and the input terminals at the extreme left center. The function switches are shown in the extended (non-depressed) position. Note that SIG LO, terminal J2, is connected to ground through different paths depending on which switch is depressed. Note, also, that A1R1 is a front panel control which allows the operator to zero the display when the unit is operating in the KΩ mode and the input leads are shorted. A1R2 is a front panel control which permits the operator to zero the display when the unit is operating in the 200MV DC range with the input leads shorted.

4-43 TX enters the diagram on the right margin and turns A1Q16 on and off. This signal is low during TX and A1Q16 is turned off. This turns off A1Q13 and, in turn, turns on A1Q9 through A1Q8. A1Q8 is connected as a low leakage diode. When A1Q13 is turned off, A1Q6 is also turned off which turns off A1Q10 through A1Q7. When TX is high, A1Q16 is turned on, turning on A1Q13 and A1Q6. A1Q9 is then turned off and A1Q10 is turned on. Thus, the non-inverting input of A1U5 will be connected to ground through A1Q10 except during TX. During TX, it will be connected to the input through A1Q9.

4-44 The output of A1U5 is connected to the summing junction through A1R52 and a 100K ohm resistor that is part of A1R51. This path is bridged in the 200MV, 2V and 200V ranges when A1K3 is closed. The current flowing to the summing junction from the output of A1U5 is then increased by a factor of 10.

4-45 INTEGRATOR

4-46 The integrator develops a ramp waveform during TX with polarity opposite that of the input. During TR, a reference voltage is integrated to drive the output of the integrator back toward zero. At some point during the TR period, the output of the integrator will pass through zero which will be sensed by the comparator, developing the 0-DET signal. The time required to drive the output of the integrator back to zero is a precise measurement of the input voltage. A simplified diagram of the integrator/-comparator circuit is shown in Figure 4-5. The common connections of A1R51 comprise the integrator summing junction. The summing junction is connected to the input of the integrator through FET's A1U9-3 and A1U9-14 which are turned off during TB1 and TB2. TB1 is the break period immediately preceeding TX and TB2 is the break period immediately preceeding TR. An operational amplifier requires a finite time to slew to a stable output level when a step signal is applied to its input. The times of TB1 and TB2 are sufficient for the amplifier to reach a stable state. Transients, due to switching, that may be present at the beginning of TB1 and TB2, will have subsided when the summing junction is connected to the input of the integrator at the end of the break periods. The charge rate of the integrating capacitor, A1C19, will be determined by the voltage level at the output of the input amplifier and the resultant current flow to the summing junction.

4-47 Counting of the clock oscillator pulses is delayed for 100 counts (100 microseconds) after the start of the TX period. In this interval, the zero detect circuit is inhibited. This prevents a 0-DET pulse from being generated by a switching transient when the input voltage to the integrator is at a very low level. Without some compensation, this would introduce an error in the time for integrating the reference to zero. Compensation is provided by a small amount of current flowing from the 10V reference (+ or −) through either A1U9-12 or A1U6-14, depending upon the input polarity. This compensation current appears as an offset at the non-inverting input of the ramp amplifier, A1U13, and has the effect of offsetting the integrator waveform the precise amount necessary for compensation.

4-48 AUTO ZERO

4-49 The auto zero circuit automatically compensates for offsets in the input amplifier or integrator circuits. Refer now to Figure 6-2. During the restoration period, (T0), which is the time from zero detect until TB1, the input of A1U5 is shorted to ground. Also, the 10V reference inputs are disconnected from the summing junction since A1U6-5 and A1U6-12 are both turned off. The level at the output of A1U13 will, therefore, be determined by the offsets of the input amplifier and integrator. A1U6-7 is turned on during T0 and A1C22 charges to the output level of A1U13 through A1R79. This offset voltage is stored in A1C22 and is the voltage level applied to the non-inverting input of the auto zero amplifier, A1U11, which operates at unity gain. The charge on A1C22 will remain from one T0 period to the

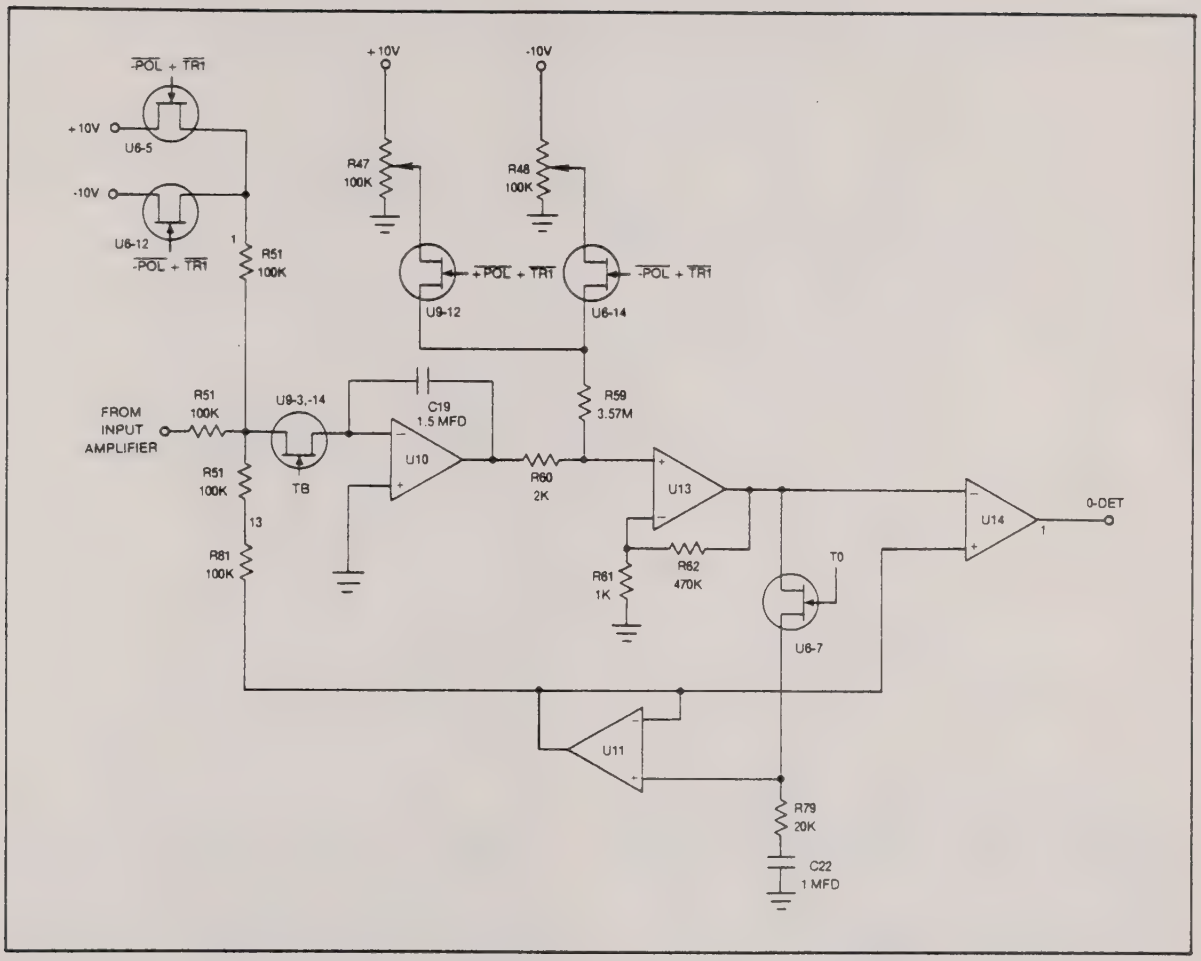


Figure 4-5. Simplified Circuit Diagram, Integrator/Comparator.

next. Therefore, the output of A1U11 forces a current through A1R81 during the integration period which nulls the error currents at the summing junction resulting from the offset voltages of the input amplifier.

4-50 COMPARATOR

4-51 Refer to Figure 4-5 which is a simplified diagram of the integrator/comparator circuits. During TR, either A1U9-12 or A1U9-14 will be turned on to offset the integrator in compensation for the 100 microsecond "throw away" period following TB2. If the output of the integrator is positive at the beginning of TR, A1U9-12 will be turned on to supply a positive current to the input of the comparator to delay 0-DET an amount that will compensate for the "throw away" period. The output of A1U13 is the amplified output of the integrator. The output polarity of the comparator will be dependent on the relative polarities of the signals at its two inputs. At some point during TR, or during TRO, the non-inverting input of A1U14-14 will pass through a level equal to the restore voltage at the output of A1U11 which is applied to the inverting input of

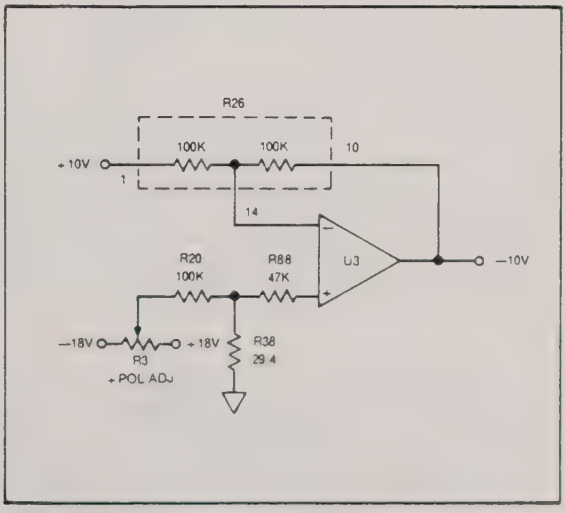


Figure 4-6. Simplified Circuit Diagram, Reference Inverter.

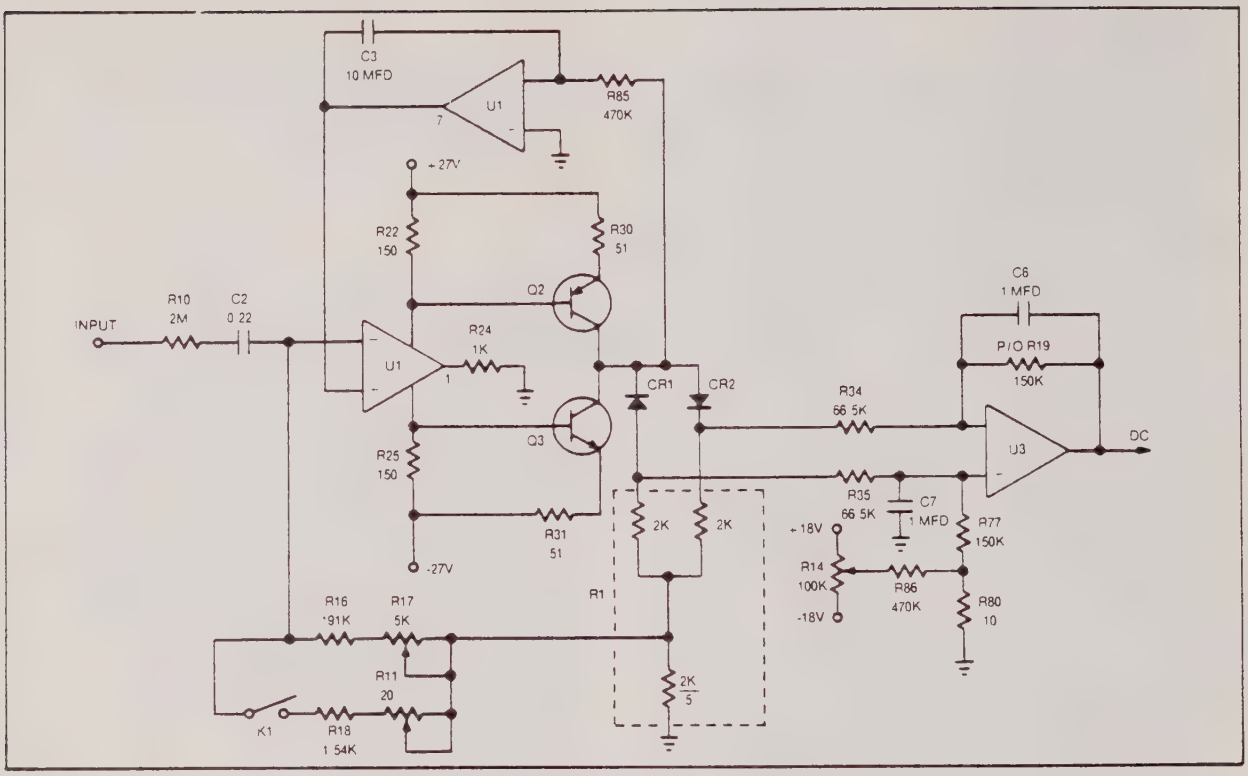


Figure 4-7. Simplified Circuit Diagram, AC Converter.

A1U14-14. The polarity of the comparator output will then be abruptly reversed, as shown in Figure 4-1, generating 0-DET.

4-52 REFERENCE INVERTER

5-53 When the DMM-53 is operating in the DC mode, operational amplifier A1U3 functions as the 10V reference inverter. A simplified schematic diagram of the reference inverter is shown in Figure 4-6. A1U3 operates in the inverting mode with +10V applied to its inverting input. Because of the ratio of the negative feedback resistors, A1U3 gain is unity, resulting in an output of −10V. −10V is required for the integrator input during TR when the input to the DMM-53 is positive. Therefore, A1R3 is labeled +POL ADJ. The function switches of the DMM-53 alter the circuit configuration of A1U3 for the different modes of operation. The connections shown in Figure 4-6 can be traced in the diagram of Figure 6-2.

4-54 AC CONVERTER

4-55 The AC Converter is a precision rectifier that produces a negative DC voltage proportional to the applied AC. This DC voltage is then applied to the input amplifier, A1U5. Figure 4-7 is a simplified schematic diagram of the AC Converter. For simplicity, some of the compensating networks have been omitted from this diagram. The input AC is applied to the inverting input of A1U1-1 through A1R10 and A1C2. The output of A1U1-1 is grounded through A1R24 which causes the operational amplifier to drive A1Q2 and A1Q3 through its supply terminals. The negative feedback path for the operational amplifier circuit is through A1CR1 and A1CR2 and the associated resistor network. This, in combination with the signal path through the other half of A1U1 to the non-inverting input of A1U1-1, maintains the gain of the system at unity. In the 200V AC and 1000V AC ranges, A1K1 is closed and the gain of this system is then reduced to 0.01. A1U3 operates as an intgrator in the AC mode. The signal applied to its two inputs are the half-wave rectified components of the input signal. A1U3 operates in the differential mode and produces a DC output proportional to the input AC. In the 200MV, 2V and 20V ranges, the overall conversion factor of the system is 1, (e.g. 2VAC input will produce −2 volts at the output of A1U3). In the 200V and 1000V ranges, the overall conversion factor is 0.01. (A 200V AC input signal will produce −2 volts at the output of A1U3).

4-56 Refer now to Figure 6-2. The circuit for the AC Converter is shown in the lower left portion of the diagram. High frequency adjustments are provided by A1C1 and A1C4. A1R17 provides a gain adjustment in the 200MV, 2V and 20V ranges and A1R11 provides a gain adjustment for the 200V and 1000V ranges. These adjustments are covered in Section V, Maintenance.

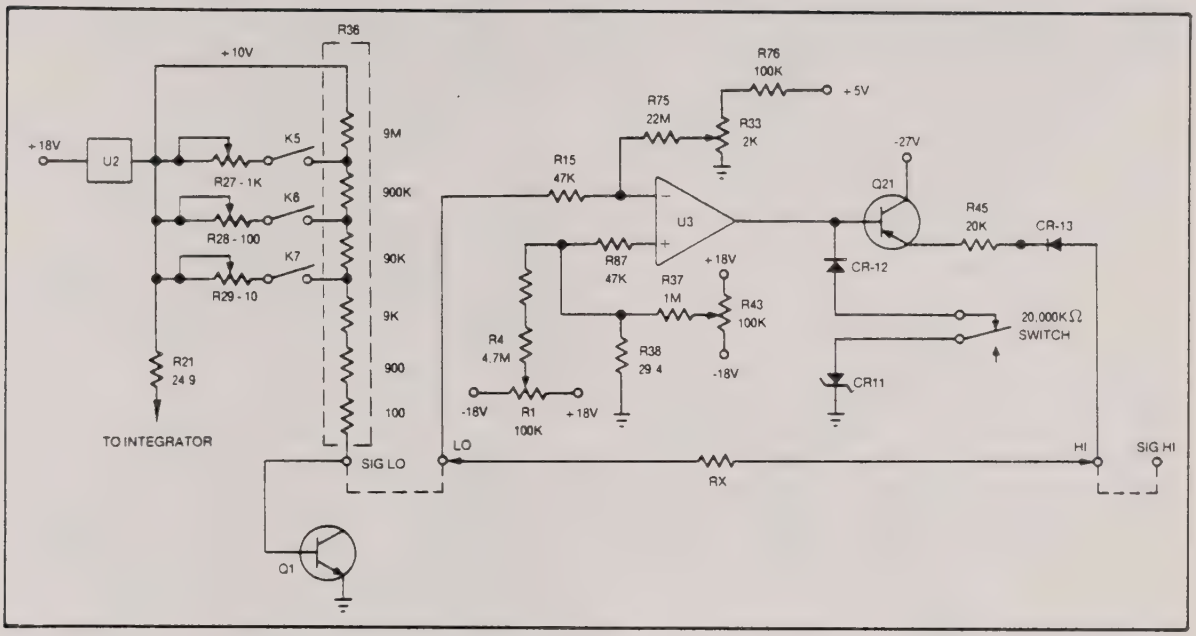


Figure 4-8. Simplified Circuit Diagram, OHMS Converter.

4-57 OHMS CONVERTER

4-58 The OHMS Converter pumps a constant and precise current through the unknown resistance. The voltage that is developed across the unknown, then provides the input to A1U5. A simplified circuit diagram of the OHMS Converter is shown in Figure 4-8. Operational amplifier A1U5, which operates as the reference inverter in the DC mode and as the integrator in the AC mode, operates as an inverting amplifier in the KΩ mode. The switch contacts which connect the various components, as shown in Figure 4-8, are omitted to simplify the diagram. The circuit of the OHMS Converter can be traced in Figure 6-4.

4-59 A1U2 provides a precise 10V to the resistor network of A1R36. Relays A1K5, A1K6 and A1K7 short out portions of A1R36 to provide larger reference currents in the lower ranges. As shown in Table 4-1, relay A1K7 closes in the 200Ω and 2KΩ ranges, range states R0 and R1. The total resistance in series with the unknown resistance is 10K ohms and the source current is 1 milliampere. Relay A1K6 closes in the 20KΩ range, range state R2. The total source resistance is 100K ohms and the source current is 100 microamperes. A1K5 closes in the 200KΩ range, range state R3. The total resistance is 1 megohm and the source current is 10 microamperes. In range state R4, the 2000KΩ range, all relays are open and the total resistance is 10 megohms. The total source current is then 1 microampere. This latter condition also exists in the 20,000KΩ range. Variable resistors A1R27, A1R28 and A1R29 provide for fine adjustments of the source currents when their respective relays are closed.

4-60 The balance of the OHMS Converter is simply an operational amplifier in which the unknown resistance provides the feedback to the inverting input. A1Q21 is part of the operational amplifier circuit and provides the necessary current gain between the output of A1U5 and the output of the circuit. A1R51 is the 20KΩ zero adjustment and A1R33 is a 2000KΩ full scale adjustment. A1Q1, A1CR11, A1CR12 and A1CR13 provide protection for the OHMS Converter should a fault condition be applied to the OHMS terminals.

4-61 ANALOG CONTROL

4-62 The switching of the analog circuits, which occurs between each state of the measurement cycle, is timed by the digital logic circuits covered in later paragraphs. The interface between that logic circuitry and the analog circuits consists of individual level shifters within A1U14 and A1U15. One input to each of the level shifters in A1U14 and A1U15 is connected to a voltage divider comprised of A1R66 and A1R67, as shown in Figure 6- 2. These inputs provide the reference level to which the logic signals are compared to accomplish the analog switching.

4-63 T0 is applied to the non-inverting input of A1U15-7 which turns on A1U6-7 to charge A1C22 during T0. TR is applied to the inverting input of A1U15-1 which back biases A1CR20 and A1U12-13. This occurs during TX and releases control of the 10V reference outputs and the compensation networks to A1U14-1 and A1U14-2. When the input to the instrument is positive, +POL goes high and −POL goes low at the end of TX. During TR, the

output of A1U14-2 will then be high. Both A1CR19 and A1CR20 will be back biased. This turns on A1U6-12 and A1U6-14 to provide a positive input to the integrator and a positive compensation current to the input of A1U13. When the input to the instrument is negative, −POL goes high and + POL goes low. This turns on A1U6-5 and A1U9-12 to provide a positive input to the integrator and a positive compensation current to the input of A1U13. Control signal TB is high during TB1 and TB2. This forces the output of A1U14-13 low during TB1 and TB2, turning off A1U9-3 and A1U9-14, disconnecting the integrator from the summing junction.

4-64 DIGITAL LOGIC CIRCUITS

4-65 The dual slope integrating process, described in the previous section, provides a precise measurement of the input voltage when the time periods for integration of the input and reference are precisely controlled. The digital logic, which is shown in Figure 6-3, provides the necessary precise timing control. In addition to the mentioned timing logic, Figure 6-3 also includes the manual and auto range control logic and the digital logic of the optional print board.

4-66 CLOCK GENERATOR

4-67 The clock generator provides the basic timing reference for the DMM-53. Refer to Figure 6-3 and the clock generator schematic which is shown in the middle left portion of the diagram. The clock generator operates at 2 MHz and is controlled by quartz crystal A1Y1. The 2 MHz oscillator output is divided by two in flip flop A1U28-9 to produce a 1 MHz pulse train.

4-68 CONVERSION LOGIC CONTROL

4-69 The several serial states in which the DMM-53 operates must be precisely measured and controlled to provide the level of accuracy guaranteed for the instrument. This precision of control results from the crystal controlled clock oscillator and the conversion control logic.

4-70 CONTROL SIGNAL GENERATOR

4-71 The conversion control logic shown in schematic form in the lower right corner of Figure 6-3 generates control signals T0, TX, TR, TRO, TB1 and TB2. The 1 MHz output of the clock generator, the 100 Hz output (1 MHz divided by 10,000) of A2U3 and 0-DET are the three inputs to these circuits. A1U17 is a dual data selector and provides the steering of the frequency signal inputs. Table 4-2 shows which of the inputs to A1U17 will appear at its output for the several states of its A SEL and B SEL inputs.

4-72 At zero detect (0-DET), shift register A1U6 is cleared and flip flop A1U22-9 is preset. This forces the output of NAND gate A1U18-3 (TB) high. (Note that counter A2U4 is reset through A1U20-11 whenever TB changes state). Counter A2U4 is clocked by the 1 MHz signal. At the count of 100, the QD output (terminal 7) of A2U4 falls, clocking A1U22-9 through A1U17-9. (Note that A1U22-5 is not clocked as it is held in a reset state). TB

Table 4-2. A1U17 Control Inputs and Signal Outputs.

	CONTROL INPUTS		SIGNAL OUTPUTS	
	TX A-SEL	TB B-SEL	A1U17-7	A1U17-9
T0	L	L	100 Hz	100K (A2U4-3)
TB1	H	H	1 MHz	80 (A2U4-7)
TX	H	L	100 Hz	80K (A2U4-9)
TB2	L	H	1 MHz	80 (A2U4-7
TR	L	L	100 Hz	100K (A2U4-3)
0-DET	L	H	1 MHz	80 (A2U4-7)
TRO	L	L	100 Hz	100K (A2U4-3)

goes low, resetting A2U4 and initiating T0. The counter is then clocked by the 100 Hz signal. At 20 counts, which is equal to 200,000 clock generator pulses, the QA output (terminal 3) of A2U4 falls and, through A1U17-9, clocks A1U22 to make TB high. This, in turn, clocks A1U16. Since the output of AND gate A1U19 is high when A1U16 is clocked, TX is clocked high at the 1Q output of A1U16. Dual counter A2U4 is reset and is now clocked by 1 MHz. This is the start of TB1. Again, at 100 counts, A1U22-9 is clocked, forcing TB low. The counters, A2U3 and A2U4, are again reset. A2U4 is now clocked by 100 Hz. At 10 counts, the QD output (terminal 9) of A2U4 falls. A1U22-9 and A1U16 are again clocked, initiating TB1.

4-73 The output of A1U19-6 was low when A1U16 was clocked, therefore, TX goes low. TX was high when A1U16 was clocked and set A1U16's 2Q output, TR, high. When TR is high, the clear signal is removed from A1U22-5. (Terminal 5 is a $\overline{Q}$ output of A1U22, but is not shown or labeled on the schematic diagram. The Q output is terminal 6). TB is now high and A2U4 is clocked by the 1 MHz signal. At 100 counts, A2U4, through A1U17-9, clocks A1U22-9 and A1U22-5. This holds TB high for another 100 counts, creating the 100 count "throw away" period at the beginning of TX (see paragraph 4-11). At the end of the "throw away", 100 count period, A1U22-5 is clocked. A1U22-9 is not clocked as it is held in a clear state due to the state of the $\overline{Q}$ output of A1U22-5. TB now goes low, the clear is removed from A1U22-9 and TR begins. A2U4 is now clocked by the 100 Hz signal and A1U22-9 is clocked when the QA output (terminal 3) of A2U4 falls at the end of 20 counts, which is equal to 200,000 counts of the 1 MHz signal. This clocks TR low and TOR low, signalling an overrange condition. TB goes high for 100 counts. 200,000 counts later, A1U22-9 is again clocked, setting TOR low and TB high. When TB goes low after 100 counts, T0 begins and a new measurement cycle begins. The 200,000

count period for TOR insures that, when operating in autorange, the instrument has settled before the next measurement cycle is initiated. The foregoing assumes zero-detect did not occur. If it had occurred during TR, A1U16 and A1U22-9 would be reset and another measurement cycle would be initiated with T0.

4-74 MANUAL RANGE CONTROL

4-75 Manual range control allows the operator to select any range he desires regardless of input signal level. It will not allow him to measure an input level greater than the full scale limit of the selected range, but he may display a measurement at something less than maximum resolution. Manual ranging is active when the AUTO push button is in its extended position, completing the path for the DOWN and UP push button circuits to the range control circuitry shown in the lower left section of Figure 6-3.

4-76 Depressing the UP push button, A1SIG, forces the output of exclusive OR gate A1U20-6 low, applying an $\overline{UP}$ clock pulse to counter A1U24. Depressing the DOWN push button similarly applies a $\overline{DN}$ clock pulse to A1U24. The output of A1U24 is applied to A1U23 which is a programmable, read-only memory, PROM, which is factory programmed as shown in Table 4-2. (Note that KΩ at terminal 13 of A1U23 is high in the DC and AC operational modes and low in the KΩ mode). A1U25-6 inhibits $\overline{UP}$ clock pulses from reaching A1U24 when range R4 has been reached. A1U25-8 similarly inhibits $\overline{DN}$ pulses when range R0 is reached. Note that the outputs of A1U23 control the closures of relays A1K1 through A1K7 in accordance with Table 4-1. Several outputs of A1U23 are applied to the display board, A2, to light the decimal points in the display as appropriate to the selected range.

4-77 When the instrument is in the KΩ mode, terminal 13 of A1U23 is low. When the 20,000 KΩ push button is depressed, the $\overline{LD}$ input, terminal 11, of A1U24 is grounded, forcing its outputs to a binary 1. All relays are, thus, de-energized and the decimal point in A2DS5 is illuminated. The UP and DOWN push buttons are ineffective since A1U24 cannot be clocked when its $\overline{LD}$ input is low.

4-78 AUTO RANGE CONTROL

4-79 When the AUTO push button is depressed, the UP and DOWN push button circuits are disconnected from the counter inputs and the range select circuitry is connected to inputs from the conversion control logic that automatically command up-ranging or down-ranging as necessary. In paragraph 4-73, it was stated that TOR went low if 0-DET did not occur within 200,000 counts from the initiation of TR. When TOR goes low, and the instrument is in autorange, a pulse is developed by the network of A1R72 (1 and 16/8 and 9) and A1C24 which is applied to the $\overline{UP}$ input of A1U24 to advance one range step. If 0-DET occurs before 10,000 counts of the 1 MHz clock generator output, a $\overline{DN}$ range pulse is generated. A description of the circuit that accomplishes this is described in the following paragraph.

Table 4-3. PROM A1U23 Programming.

PROM ADDRESS IN HEX	PROGRAMMED CODE	REMARKS
00	FF	
01	FF	
02	FF	
03	FF	
04	FF	
05	FF	
06	FF	
07	FF	
08	FF	All Relays Deenergized
09	FF	
0A	FF	
0B	FF	
0C	FF	
0D	FF	
0E	FF	
0F	FF	
10	96	R0
11	9D	R1
12	BB	R2
13	A7	R3
14	BF	R4 (KΩ)
15	BF	R4
16	BF	R4
17	BF	R4
18	B6	R0
19	BD	R1
1A	FB	R2
1B	37	R3
1C	7F	R4 (DC ÷ AC)
1D	7F	R4
1E	7F	R4
1F	7F	R4

4-80 Flip flop A1U21-5 is held in a preset state during TX by TX being low. At TR, TX goes high, removing that preset from A1U21-5. A1U21-5 will be clocked by the first positive-going edge of the 100 Hz clock signal, disabling NAND gate A1U25-11. If 0-DET occurs before A1U21-5 is clocked, the output of A1U25-11 will go low, applying a $\overline{DN}$ clock pulse to counter A1U24. If 0-DET has not occurred

before A1U21-5 is clocked, the disabling of A1U25-11 will prevent generation of the $\overline{DN}$ pulse. When TOR goes low, an overrange condition, it generates a negative going pulse at the junction of A1C24 and the two elements of A1R72, that applies an $\overline{UP}$ pulse to A1U24 to increase the range by one step. The $\overline{UP}$ and $\overline{DN}$ pulses are inhibited from clocking the counter in autorange in the same manner as in the manual range control mode.

4-81 POLARITY LOGIC

4-82 The polarity logic makes a determination of input polarity and selects the appropriate polarity of the 10 volt reference and illuminates the appropriate polarity indication in the display. It is shown in the left center portion of Figure 6-3. The polarity of the 0-DET line will be opposite of the input polarity at the end of TX. This is clocked through A1U28-5 by TR at the 2Q output of A1U16 if the instrument is operating in the DC mode. (A1U28-5 is held in the preset condition and NAND gates A1U18-6 and A1U18-8 are disabled by DC being low in the AC and KΩ modes). If 0-DET is low at the beginning of TR, the output of A1U18-6 will go low to light the plus (+) display. If it is positive, the output of A1U28-8 goes low to light the minus (−) display. The Q and $\overline{Q}$ outputs of A1U28-5 are the +POL and −POL signals applied to the analog level shifters, as described in paragraph 4-61, and which accomplish the appropriate reference voltage polarity switching.

4-83 0 DET LOGIC

4-84 When 0-DET occurs, it resets the conversion control logic to initiate another measurement sequence of T0, TX and TR. This was discussed in paragraph 4-72. The signal that resets the conversion control logic is not 0-DET directly from the analog circuits. Rather, it is triggered by 0-DET. The conversion control logic assures that 0-DET does not trigger the reset at an improper time. The reset signal can only be generated after TB2 and the following 100 count "throw away" period are terminated.

4-85 In paragraph 4-81, it was described how A1U28-5 was clocked at the end of TX. The polarity of the 0-DET line at that time is preserved at the Q output of A1U28-5. The 0-DET line and the Q output of A1U28-5 are applied to exclusive OR gate A1U20-3. Immediately following the TX to TR transition, both inputs to A1U20-3 are of the same level and its output is low. At zero detect, 0-DET transitions to low and the output of A1U20-3 goes high. This transition passes through NAND gate A1U25-3 and through AND gate A1U19-11, stopping the clock output from clocking flip flop A1U28-9. It also presets A1U28-9. The output transition of A1U25-3 is delayed by A1R72 (15 and 2) and A1C25 for approximately 10 microseconds before the reset of A1U16 and preset of A1U22-9 is accomplished.

4-86 To insure that a transition of 0-DET does not reset the conversion control logic prematurely, A1U25-3 is disabled until the output of A1U18-3 goes low at the end of the 100 count "throw away" period. One input to A1U25-3 is the output of AND gate A1U19-8. A1U19-8 is enabled by TR. Therefore, A1U25-3 will be disabled during T0 and TX. When TR goes high, TB, at the output of A1U18-3, is also high and inverted to a low at the input of A1U19-8 by A1U26-2. When TB goes low at the end of the "throw away" period, the output of A1U19-8 goes high, enabling A1U25-3 to pass the 0-DET pulse.

4-87 DISPLAY LOGIC

4-88 The display logic is controlled by inputs from the conversion control logic and the range logic. At 0-DET, if the input is within full scale of the selected range, the count of clock pulses will be displayed. The count display will remain until the next 0-DET occurs, when it will be updated. The display logic circuits are contained within the A2 area of Figure 6-3.

4-89 The clock generator output, 1 MHz, is applied to the CK input of A2U3. A2U3 contains a bank of four decade counters which are driven by the CK input. These are reset each time that the output of A1U18-3 goes high. They are reset at TB2 and begin counting the clock at the end of the "throw away" period. At zero detect, A2Q6 is momentarily turned on to load the counter outputs into internal four-line storage latches of A2U3. A scanning generator sequentially connects each four-line latch output to output terminals. Four other strobe output lines, ST1 through ST4, are sequentially enabled synchronous with the latch outputs. The strobe lines drive individual transistors to sequentially enable display devices A2DS-3 through A2DS-6. The latch outputs of A2U3 are applied to decoder A2U2 which drives the displays in parallel. This constitutes the multiplexed display drive.

4-90 The first section of counter A2U4 drives decoder/-latch/driver, A2U1, which drives A2DS-2. A2U4 is counting the 100 Hz clock signal of which each pulse is equal to 10,000 pulses of the 1 MHz clock signal. This provides the BCD input for the second most significant figure in the display. The second section of A2U4 is connected to the display through flip flop A1U21-9. If the count at zero detect has progressed to 100,000, or more, the QA output (terminal 3) of A2U4 will be high. 0-DET will clock this through A1U21-9 to its Q output turning on the "1" display in A2DS-1. If the count is less than 100,000, the input to A1U21-9 will be low. Its Q output will be low and the "1" display in A2DS-1 will not be illuminated.

4-91 When an overrange condition occurs, TOR goes low, blanking the displays connected to A2U7 and A2U2 and clearing A1U21-9. The displays are blanked until 0-DET resets the conversion control logic. This causes the display to blink once each time the overrange condition occurs. If the operator does not advance the instrument to a higher range or if the input is beyond the range of the instrument, the display blinks at the measurement sequence rate of once-per-second.

4-92 PRINT BOARD LOGIC

4-93 The print board is an item of optional equipment that, in effect, parallels the display to provide a BCD output to an external, computer, hard copy printer or other device. The print board logic is shown in the upper left corner of Figure 6-5.

4-94 The print board has its own power transformer and +5V power supply. The connections between the main board logic and print board logic are accomplished through photo-couplers on the print board. Note that those devices on the print board that are connected to the main board logic are powered from the main board +5V supply while those on the other side of the photo-couplers are powered by the print board supply. The clock generator output, A1U28-9, is applied to the print board through A3CR3. TR is applied through A3CR2. When TR is low, the clock is inhibited from clocking the devices on the print board because of the common connection of these two diodes. So during TR, the clock pulses pass through the photo-couplers to the print board logic. If $\overline{\text{HOLD}}$/READ is high, with the first pulse, NAND gate A3U8-6 will preset flip.flop A3U5-5 and reset the counters. The latter is accomplished through exclusive OR gate A3U7-3. The pulse train then pulls the output of A3U8-11 low, disabling A3U8-6 and removing the preset from A3U5-5 and the clear from the counters. The Q output of A3U5-5 enables A3U8-3 and its output falls to send the first clock pulse to the counters. The pulse train pulls the collector of A3Q1 low and it is held low by A3C3 until 0-DET stops the clock generator. It then goes high to clock A3U5-5. This disables A3U8-3 from passing pulses to the counter chain and generates DATA GATE at the Q output of A3U5-5. (If $\overline{\text{HOLD}}$/READ is then set low, the next measurement sequence will not clock the print board counters. Thus, the external device may operate at a slower rate than the DMM-53).

4-95 When a range change occurs, manually or automatically, the Ra input to the print board will change state. Through A3U7-8, timer A3U9 is triggered, resetting the counters through NAND gate A3U8-8 and exclusive OR gate A3U7-3. They will be held in the reset state for two seconds. The DMM-53 can then autorange to a range that will accomodate the input before A3U9 times out. This provides first reading accuracy from the print board output. Since counter A3U3 is operating at 1 MHz, its outputs are buffered to prevent line capacity from affecting its operation.

4-96 +Polarity is coupled through the print board and will be negative in KΩ and AC modes and will be positive or negative depending on instrument input in the DC mode.

SECTION V
MAINTENANCE

5-1 GENERAL

5-2 This section of the manual contains instructions for periodic maintenance, calibration, troubleshooting and repair of the Model DMM-53 Digital Multimeter.

5-3 TEST EQUIPMENT

5-4 The test equipment required for adjusting and troubleshooting the DMM-53 Digital Multimeter is listed in paragraph 5-15.

5-5 PREVENTIVE MAINTENANCE

5-6 Careful and regular performance of periodic preventive maintenance will reduce the probability of failure and the need for corrective maintenance.

5-7 INSPECTIONS

5-8 Perform periodic inspections as follows:

PERIOD	AREA OF INSPECTION	ITEMS TO BE CHECKED
Weekly	Exterior of Unit, particularly the front and rear.	Controls, indicators and connectors for dust, dirt, security of connections, signs of damage.
When performing calibration.	Interior of Unit.	Electrical parts and wiring, including printed circuit wiring, for dust, dirt, corrosion, evidence of overheating and other damage.

5-9 CLEANING

5-10 Remove dust, dirt and other foreign material using a small brush and vacuum cleaner. Low pressure air may be used if a vacuum cleaner is not available. When using the air, be sure to aim the air stream so that the foreign material will be blown out of the unit rather than into recesses, slots, etc. Use a cloth and a suitable solvent to remove material not removable by means of the above procedure.

CAUTION

Take care not to scratch the printed circuit wiring if it is necessary to brush or rub it to remove foreign material. Avoid the use of chemical cleaning agents which might damage the plastics used in this instrument. Avoid chemicals which contain benzine, toluene, xylene, acetone or similar solvents. If solvent is used, allow all areas to thoroughly air dry prior to placing instrument in use.

5-11 LUBRICATION

5-12 No lubrication is required.

5-13 PERFORMANCE TEST

5-14 The performance test consists of removing normal inputs to the multimeter and performing the preliminary checks and adjustments of paragraph 2-15 of this manual.

5-15 TEST EQUIPMENT REQUIRED

5-16 The test equipment required to troubleshoot or calibrate the DMM-53 Digital Multimeter is listed in Table 5-1.

5-17 TROUBLESHOOTING

WARNING

HIGH VOLTAGE (117V AC). This equipment is powered by potentially lethal voltages.

DEATH

on contact may result if personnel fail to observe safety precautions. The 117V AC (or 220V AC) input power connections are exposed at the right rear corner of the circuit board adjacent to the power transformer. Avoid contact with these exposed voltages when adjusting or maintaining the instrument. Remove the power cord from the wall receptacle when removing or replacing parts on the circuit board.

Table 5-1. Required Test Equipment.

EQUIPMENT	RECOMMENDED EQUIPMENT	SPECIFICATIONS REQUIRED
DC Standard	Fluke 335D	± 0.003%
Polarity Switch	Any	Double Pole Double Throw
AC Standard	HP 745/746	± 0.06% Accuracy on 1, 10, 100 and 1000V AC ranges at 300 Hz and 30 KHz.
Resistance Standard	Four Terminal Standard Resistors.	Four-Terminal Standards ± 0.005% at 1K, 10K,100K. ±0.1% at 1M and 10M.

CAUTION

Maintenance should be attempted only by qualified electronic technicians with some training in digital logic techniques and only after a thorough study of the principles of operation described in detail in Section IV.

5-18 As an aid to troubleshooting of the DMM-53 Digital Multimeter, Table 5-2 is included in this section and presents a number of items that the technician may check which may help him determine the area of the circuit where the malfunction has occurred. If not previously accomplished, a thorough study of the Principles Of Operation of Section IV should be undertaken. The information presented in that section provides a foundation for logical troubleshooting of the DMM-53.

5-19 CALIBRATION PROCEDURE

5-20 The calibration procedures require the test equipment listed in Table 5-1. Wherever voltages or resistances are specified, they are to be precise and within the tolerance specified in Table 5-1. Allow one hour for warm-up with the cover in place before removing the cover as directed in paragraph 5-37. Figure 5-1 shows the location of all adjustments required in the calibration procedure. All adjustments, to which access is required during calibration, are located so that they are accessible without removing the optional print board, if installed. When the cover has been removed, proceed with the calibration of the instrument in the order presented in the following paragraphs.

Table 5-2. Troubleshooting Guide.

CHECK	CHECK FOR
A1U14 and A1U15 Level Shifters.	+17VDC and −17VDC excursion with change of level at logic signal inputs.
FET Switches.	"Pinch-off" voltage. Gate −5V with respect to any other element.
Integrator, A1U10, Output.	Linearity of ramp waveform. Amplitude of ramp for given input.
Ramp Amplifier, A1U13.	Gain of from 400 to 500.
Input Amplifier, A1U5.	Gain of 1 in 2000V, 200V, 20V and 2V ranges. Gain of 10 in 200MV range.
Relays A1K1 through A1K7.	For closures in accordance with Table 4-1.
10V Reference Balance Control, A1R42.	Balanced +10V and −10V at arm of A1R42 with negative and positive inputs, respectively.

Table 5-3. Power Supply Voltage Limits.

TEST POINT	SUPPLY	LIMITS
TP1	+27	+25.5 to +28.5V DC
TP2	−27	−25.5 to −28.5V DC
TP3	+18	+17.2 to +18.7V DC
TP4	−18	−17.2 to −18.7V DC
	+5	+4.75 to +5.25V DC

5-21 POWER SUPPLY CHECKS

5-22 Connect the DMM-53 power cord to a source of 117V AC (103.5 to 126.5V RMS) or 220V AC (198 to 242V RMS) as appropriate to the setting of the power selector switch, A1S2, located adjacent to the power transformer, A1T1. Depress the POWER push button on the front panel and verify that the display is illuminated. Check the power supplies in accordance with the information contained in Table 5-3. If the voltages are not within the limits specified therein, troubleshoot the power supply. If the optional print board is installed, the 5 volt supply for that unit should be checked and should be within the limits of +4.75 to +5.25 volts.

5-23 DC ZERO

1. Select the DC function and the 200MV range. Turn adjustments A1R48 and A1R47 counterclockwise to their limits. The front panel ZERO control is a 20-turn potentiometer. Center this control by turning it to its end limit and reversing rotation for 10 turns.

2. Short the input terminals. Display should alternately indicate +00.000 and −00.000. If the + and − signs do not alternate, adjust A1R58 for that indication.

NOTE

A1R58 should not require adjustment unless a component has been changed or if DC measurements are not adjustable to specification.

3. Connect the DC standard to the input terminals. Select the 2V range and adjust the DC standard to +0.00010 volts. Adjust A1R48 for display of alternating +.00010 and +.00009.

4. Adjust the DC standard to −0.00010 volts and adjust A1R47 for display of alternating −.00010 and −.00009.

5. If A1R58 has been adjusted, apply a piece of pressure sensitive tape to its top surface to insure against accidental rotation. Disconnect the DC Standard.

5-24 REFERENCE AMPLIFIER ZERO

NOTE

This adjustment is not required unless potentiometer A1R1 cannot be properly adjusted.

5-25 The following steps zero the inverting amplifier, A1U3, by forcing the KΩ function. The amplifier is zeroed by shorting its feedback path. (See paragraph 4-57). The procedure follows:

1. Electrically center A1R1 (mΩZERO). Select the KΩ function and the 20KΩ range.

2. Short the ΩHI and ΩLO terminals together and connect them to the SIG HI terminal.

3. Adjust A1R43 for display of 0.0000 ±1 digit by ***first adjusting for a reading other than zero and then reversing the adjustment to achieve the zero display.*** This insures that the adjustment is not made too far into the zero range which will result in erroneous indications. Apply a paper seal to A1R1.

5-26 TURNOVER ADJUSTMENT

5-27 The TURNOVER adjustment need not be made during routine calibration. A1R42 is the turnover adjustment and is adjusted so that equal display indications are obtained with ±10V inputs when A1R3 is centered. In some instances, A1R3 may have to be slightly off-center to allow for proper adjustment. Proceed as follows:

1. Center A1R3 (+POL ADJ). Rotate A1R52 (−POL ADJ) to its clockwise stop.

2. Select the VDC function and the 20V range. Connect the DC standard to the input terminals and set its output to −10.0000 volts. Record the display reading.

3. Set the DC standard output to +10.0000V and record the display reading.

4. Subtract the smaller of the two readings obtained in steps 2 and 3 from the larger and divide the difference by 2.

5. If the reading obtained in step 3 was larger than that obtained in step 2, adjust A1R42 to reduce the display reading by the number resulting from the computation of step 4. If the reading obtained in step 3 was smaller than the reading obtained in step 2, adjust A1R42 to increase the display reading by the number obtained in the computation of step 4.

6. Set the DC standard to −10.0000 volts and check display indication. It should be ±10 digits from the computed value and greater than −10.0010. If the indication is greater than 10.0010 but is greater than ±10 digits from the computed value, repeat steps 2

through 5. If the indication is less than −10.0010, adjust A1R42 for display indication of −10.0010 and proceed to step 8.

7. Rotate A1R52 to its counterclockwise stop. If the display indication is greater than −9.9990, adjust A1R42 for a display reading of −9.9990.

8. Seal A1R42 with a piece of tape to prevent accidental rotation.

NOTE

The turnover adjustment is accomplished to obtain a balance between the + and − display readings for equal input levels. It is not the final DC calibration. A precise adjustment of display readings for given inputs is accomplished under DC calibration in paragraph 5-28.

5-28 DC CALIBRATION

5-29 Connect the DC standard to the input terminals. Proceed with the DC calibration steps of Table 5-4.

5-30 INPUT BIAS ADJUSTMENT

1. Select the VDC function and the 200MV range and short the input connectors (SIG HI to SIG LO).

2. Adjust the front panel ZERO control for a display indication of ±00.000.

3. Remove the short from the signal input and insert a 1 megohm resistor, with short leads, across the signal input terminals.

4. Adjust A1C8 for a front panel indication of ±00.000.

5-31 K OHMS CALIBRATION

NOTE

A1R21 is not adjusted during a normal calibration of the KΩ function.

5-32 Using the four-wire resistance measuring connections described in Section III, perform the OHMS calibration steps of Table 5-5. If the proper display in-

Table 5-4. DC Calibration Adjustments.

STEP	RANGE	INPUT	ADJUSTMENT	DISPLAY
1	200MVDC	0 (Shorted Leads)	MV Offset	00.000 MV
2	2VDC	−0.00010VDC	R47	−10/9
3	2VDC	+0.00010VDC	R48	+10/9
4	20VDC	−13.0000VDC	R52	−13.0000
5	20VDC	+13.0000VDC	R3	+13.0000
6	2VDC	+1.30000VDC	R55	+1.30000
7	200MVDC	+0.100000VDC	R57	+100MV
8	200VDC	+130.000VDC	R6	+130.000

Table 5-5. K OHMS Calibration Adjustments.

STEP	RANGE	INPUT	ADJUSTMENT	DISPLAY
1	200 OHMS	0 (Short)	OHMS Offset	00.000
2	2KΩ	1.00000K Ohms	R29	1.00000
3	20KΩ	10.0000K Ohms	R28	10.0000
4	200KΩ	100.000K Ohms	R27	100.000
5	2000KΩ	1000.00K Ohms	R33	1000.00

Table 5-6. AC Calibration Adjustments.

STEP	RANGE	INPUT	ADJUSTMENT	DISPLAY
1	*2VAC	0.00100VAC at 300 Hz	R14	.00100
2	200VAC	100.000VAC at 300 Hz	R11	100.000
3	200VAC	100.000VAC at 30 KHz	C1	100.000
4	20VAC	10.0000VAC at 300 Hz	R17	10.0000
5	20VAC	10.0000VAC at 30 KHz	C4	10.0000
*See Text				

dication cannot be obtained when performing any one of the steps of Table 5-5, adjust AR21 to obtain the specified display indication, plus 10 extra digits. Then repeat all steps of Table 5-5.

5-33 AC CALIBRATION

NOTE

The AC Converter zero adjustment (Step 1, A1R14, Table 5-6) is normally performed with an input voltage other than 0V AC (0.000100V AC). An alternate method is to short the input jacks and adjust A1R14 to obtain a zero display reading, taking precautions not to back the potentiometer too far into the zero region. The instrument top cover will influence the reading when the zero is obtained in this manner. Several attempts may be required to obtain a good zero. This procedure will, also, slightly degrade the AC Converter performance.

5-34 Connect the AC standard to the input terminals and perform the AC Calibration steps of Table 5-6.

5-35 DISASSEMBLY/REASSEMBLY

5-36 The following paragraphs outline the procedure for obtaining access to the internal components of the DMM-53. In all cases, reassembly is accomplished using the reverse procedure.

5-37 COVER REMOVAL

5-38 Set the instrument on the bench with its top side down. Remove the four Phillips head screws accessible through the center of each rubber foot. Then turn the unit over and lift the cover clear by applying light pressure under its forward and rear lips.

5-39 PRINT BOARD REMOVAL

5-40 If the optional print board is installed, it may be removed by removing the two screws through the rear panel connector and the single screw through the circuit board near its forward edge. The circuit board may then be pulled slightly forward and rotated to the right to expose its undersurface. To remove the board completely, unsolder the two power leads that run from the print board to the main board, at the main board. Then unplug the IC connector on the main board and lift the print board clear.

CAUTION

The power leads to the print board are connected to the 117V AC input and pose a lethal hazard to operating personnel if the power cord is not removed from the wall receptacle when servicing the unit.

5-41 MAIN BOARD REMOVAL

5-42 To remove the main circuit board, first remove the cover (paragraph 5-37) and the print board (paragraph 5-39) if installed. Lift the case side members clear by grasping the handle pivots and, with a gentle rocking motion, apply upward pressure. This removes the side plates of the case. Grasp the front and rear panels and lift the board clear of the case. Note that the front and rear panels fit into grooves in the bottom, sides and top of the case.

CAUTION

When the circuit board is removed from the case, the 117V AC primary power connections are exposed. This presents a lethal hazard to operating personnel if the power cord is not removed from the wall receptacle when the circuit board is being serviced.

5-43 DISPLAY PANEL AND CIRCUIT BOARD REMOVAL

5-44 To remove the front panel, first remove the cover, print board and main circuit board (paragraphs 5-37 through 5-42). Unsolder the four leads to the front panel input terminals noting which wire or component connects to each terminal. Remove the front panel. Remove the two screws that attach the display board to the switch assembly and lift the board upward to clear the switch assembly. Disconnect the ribbon cable connectors from the mating connectors on the display panel.

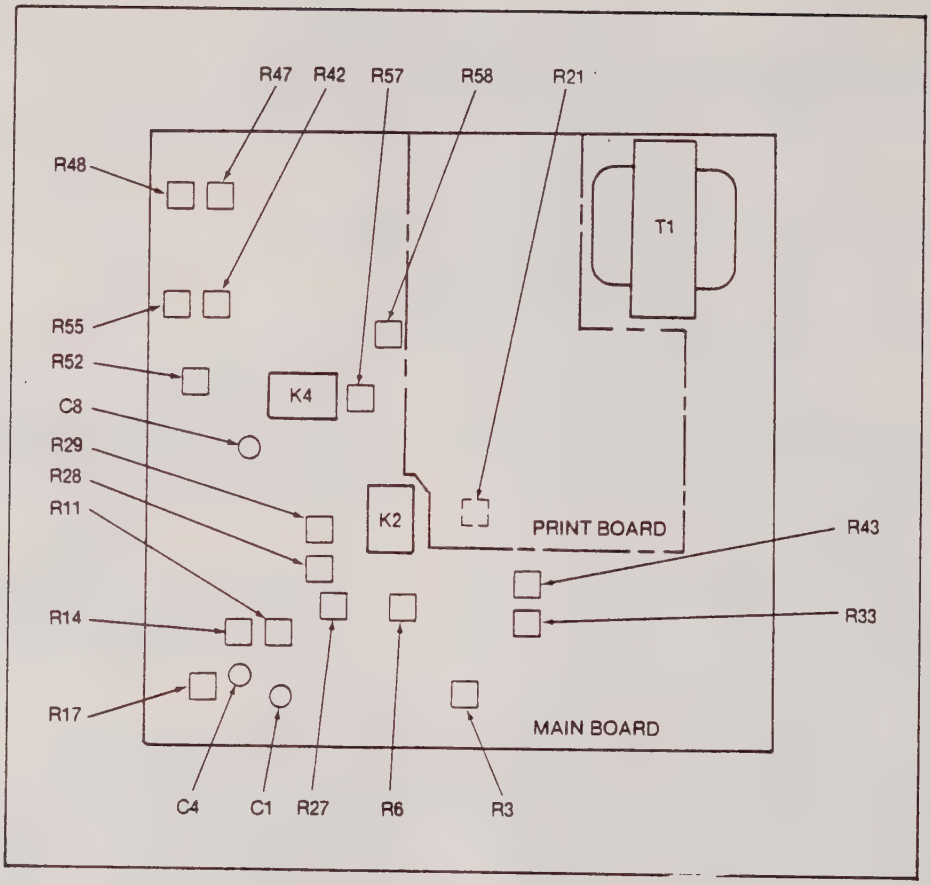


Figure 5-1. Calibration Adjustment Locations.

SECTION VI
DIAGRAMS

6-1 GENERAL

6-2 This section of the manual contains schematic and mechanical diagrams necessary for operation and maintenance of the Model DMM-53 Digital Multimeter. The schematic diagrams illustrate the circuits while the mechanical assembly drawings indicate the component locations.

6-3 REFERENCE DESIGNATIONS

6-4 Partial reference designators are shown on the schematic and mechanical drawings. Prefix these reference designators with assembly and/or subassembly designation for the complete reference designator. For example:

Assembly/Sub-Assembly	Component	Component Designation
None	T1	T1
A1	U6	A1U6
A2	R44	A2R44
A3	C7	A3C7

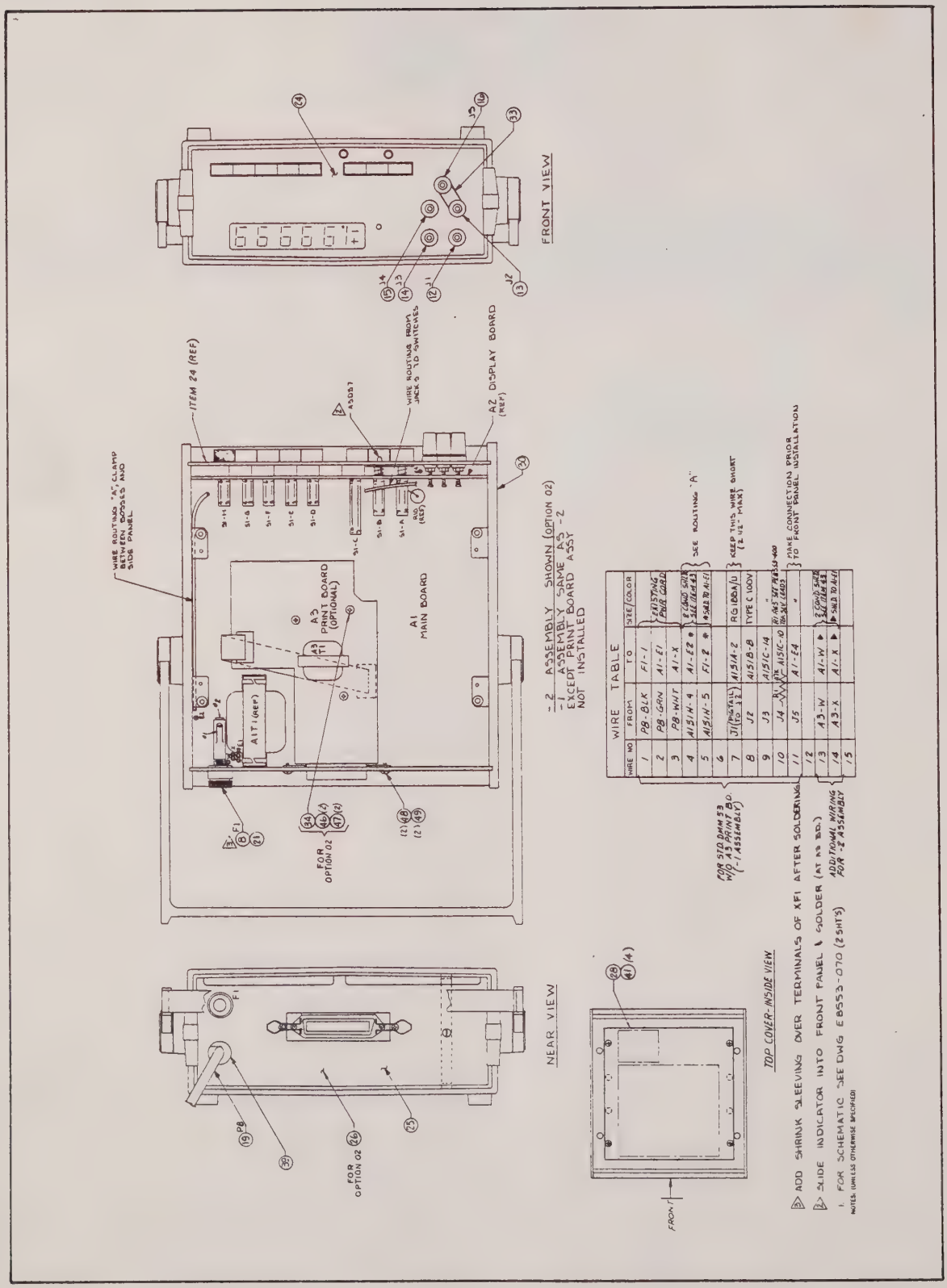

FRONT VIEW
NEAR VIEW
TOP COVER-INSIDE VIEW
A1 MAIN BOARD
A3 PRINT BOARD (OPTIONAL)
A2 DISPLAY BOARD (REF)
ITEM 24 (REF)
WIRE ROUTING "A" CLAMP BETWEEN BOSSES AND SIDE PANEL
WIRE ROUTING FROM JACK & LID SWITCHES
FOR OPTION 02
-2 ASSEMBLY SHOWN (OPTION 02)
-1 ASSEMBLY SAME AS -2 EXCEPT PRINT BOARD ASSY NOT INSTALLED
WIRE TABLE
WIRE NO | FROM | TO | SIZE/COLOR
1 | P8-BLK | A1-E1 | EXISTING PWR CORD
2 | P8-GRN | A1-E1 | "
3 | P8-WHT | A1-X | "
4 | A1J1H-4 | A1-E2 * | #22AWG SOLID SEE NOTE #3
5 | A1J1H-5 | A1-E2 * | #22AWG SOLID SEE NOTE #3
6 | | | SEE ROUTING "A"
7 | J1(DIGITAIL TO J2) | A1J1A-2 | RG 180A/U
8 | J2 | A1J1B-B | TYPE C 100V
9 | J3 | A1J1C-14 | "
10 | J4 | A1J1C-10 | "
11 | J5 | A1-E4 | "
12 | | | KEEP THIS WIRE SHORT (2 1/2" MAX)
13 | A3-W | A1-W | #22AWG SOLID
14 | A3-X | A1-X | #22AWG SOLID
15 | | | MAKE CONNECTION PRIOR TO FRONT PANEL INSTALLATION
FOR STD DMM-53 W/O A3 PRINT BD. (-1 ASSEMBLY)
ADDITIONAL WIRING FOR -2 ASSEMBLY
FROM F1
ADD SHRINK SLEEVING OVER TERMINALS OF XF1 AFTER SOLDERING
SLIDE INDICATOR INTO FRONT PANEL & SOLDER (AT NO END.)
1. FOR SCHEMATIC SEE DWG E8553-070 (2 SHTS)
NOTES: (UNLESS OTHERWISE SPECIFIED)

Figure 6-1. Unit Assembly Diagram, DMM-53 Multimeter.

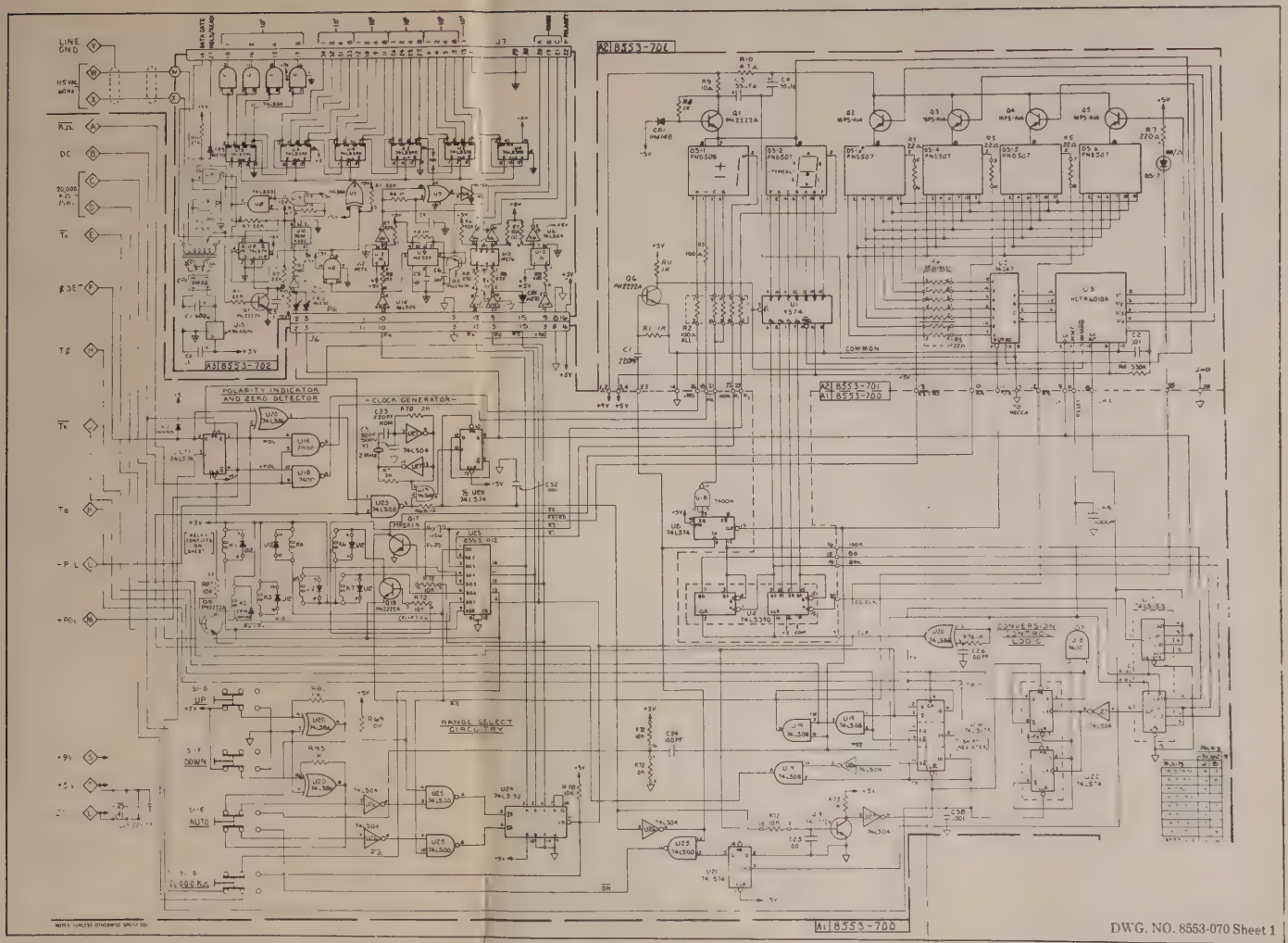


Figure 6-2. Schematic Diagram, Analog Circuits (A1).

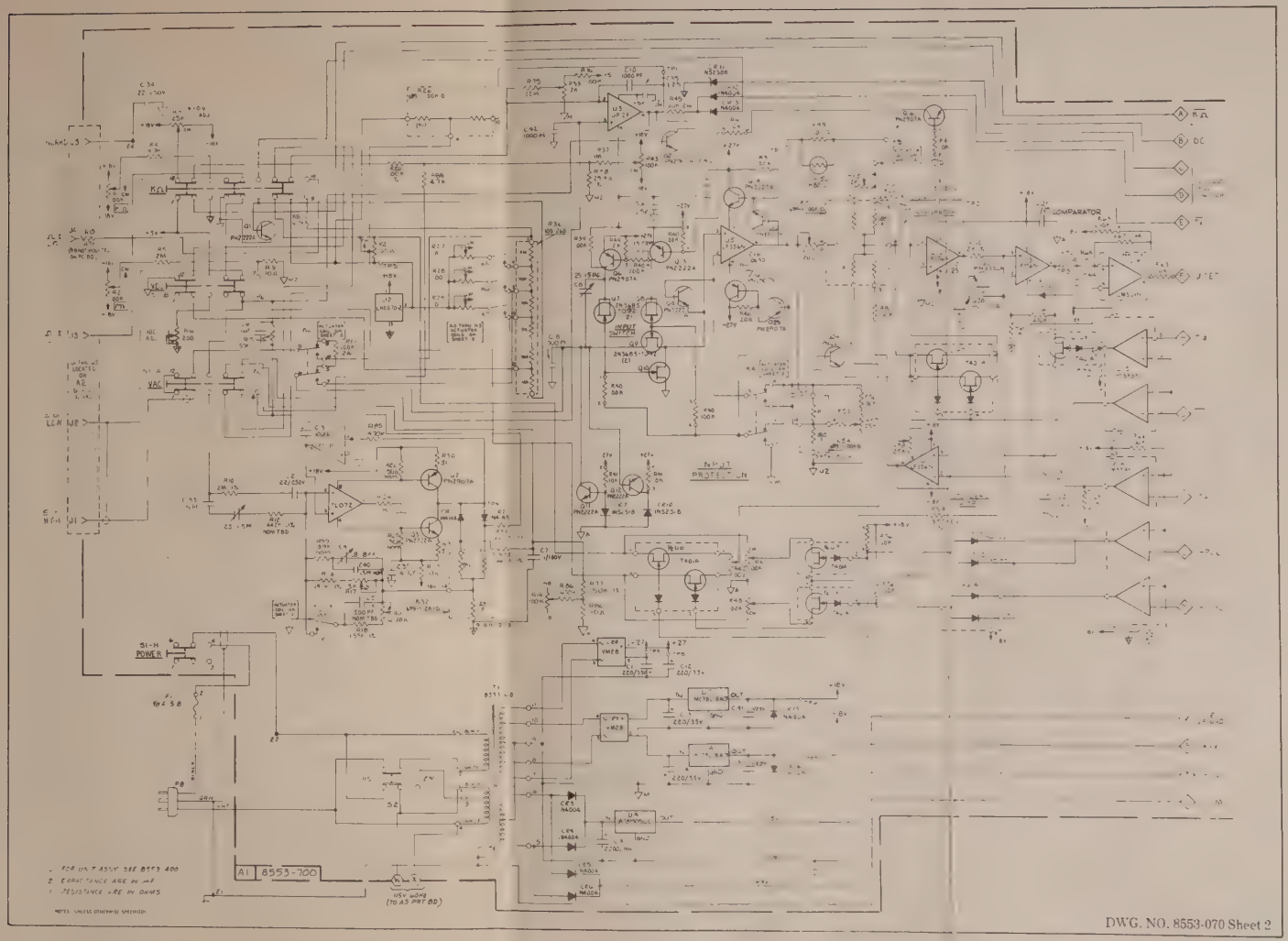
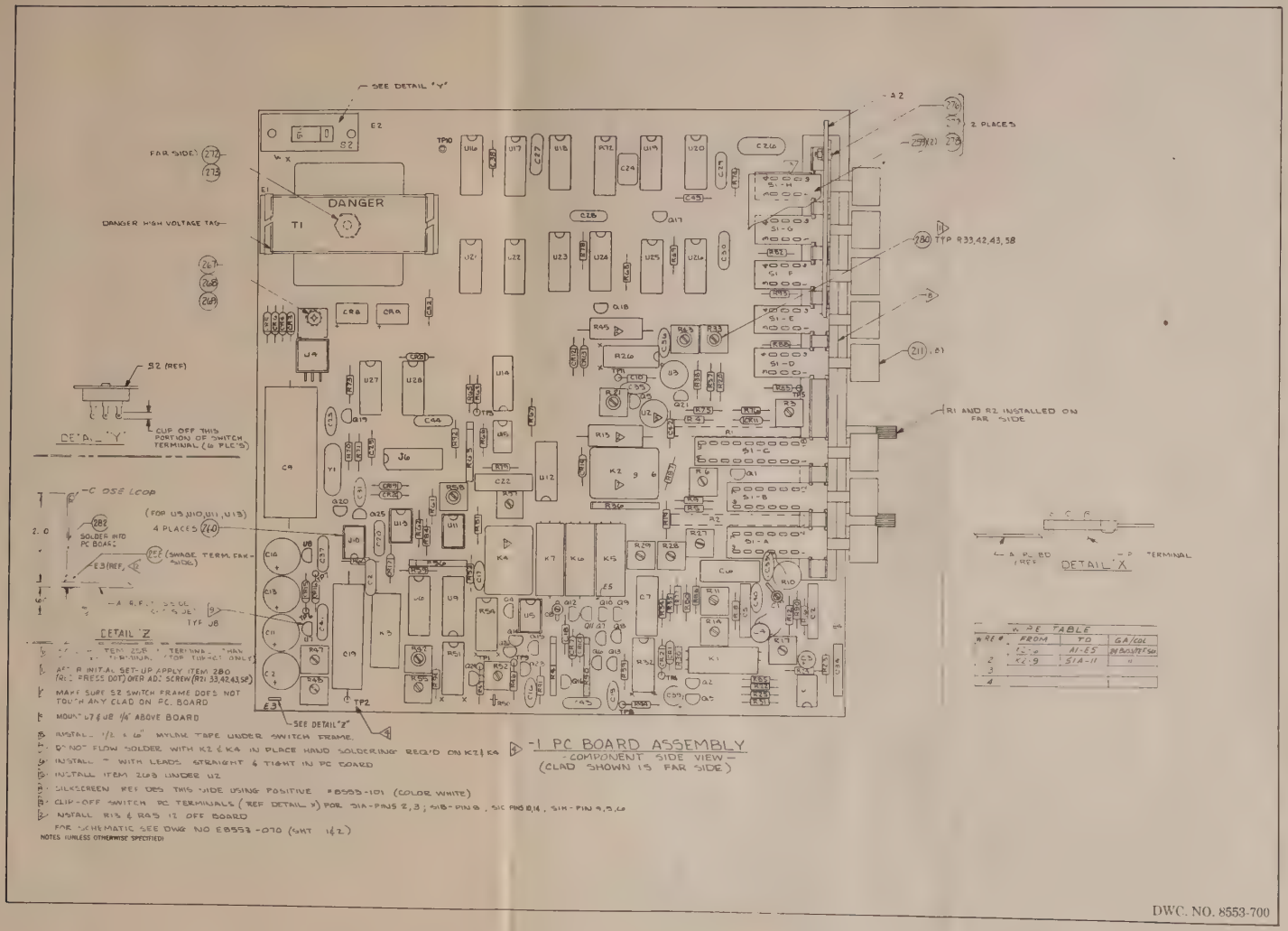


Figure 6-3. Schematic Diagram, Digital Circuits (A1, A2 and A3).

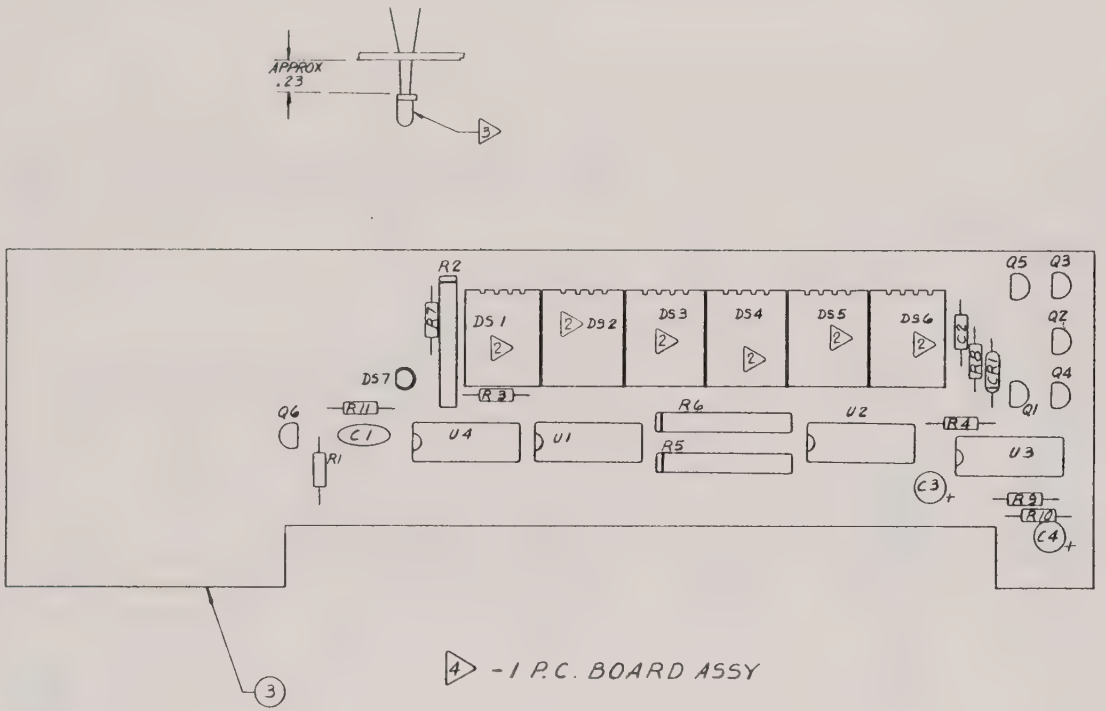


NOTES (UNLESS OTHERWISE SPECIFIED)

1. INSTALL ITEM 268 UNDER U2.
2. SILKSCREEN REF DES THIS SIDE USING POSITIVE #8553-101 (COLOR WHITE)
3. CLIP-OFF SWITCH PC TERMINALS (REF DETAIL 'X') FOR SIA-PINS 2,3; SIB-PIN 9, SIC PINS 8,14, SID-PIN 4,5,6
4. INSTALL R13 & R45 IN OFF BOARD
   FOR SCHEMATIC SEE DWG NO 8553-070 (SHT 1&2)

DWG. NO. 8553-700

Figure 6-4. P.C. Board Assembly, Analog/Digital (A1).



4 COMPONENTS MUST NOT PROJECT PAST DISPLAY (DS1-DS6)

3 INSTALL WITH FLAT IN BASE AS SHOWN IN FRONT VIEW, LEAVE LEADS LONG & DO NOT SOLDER. SPREAD LEADS LIGHTLY TO KEEP INDICATOR IN PLACE

2 NOTE: ONLY THESE CLEANING SOLUTIONS ARE ALLOWED WHEN DISPLAYS ARE ON BOARD: FREON TF, METHYL ALCOHOL, ISOPROPYL ALCOHOL, OR WATER.

1. FOR SCHEMATIC SEE DWG. NO. E8553-070 SHT. 2

NOTES (UNLESS OTHERWISE SPECIFIED)

DWG. NO. 8553-701

Figure 6-5. P.C. Board Assembly, Display (A2).

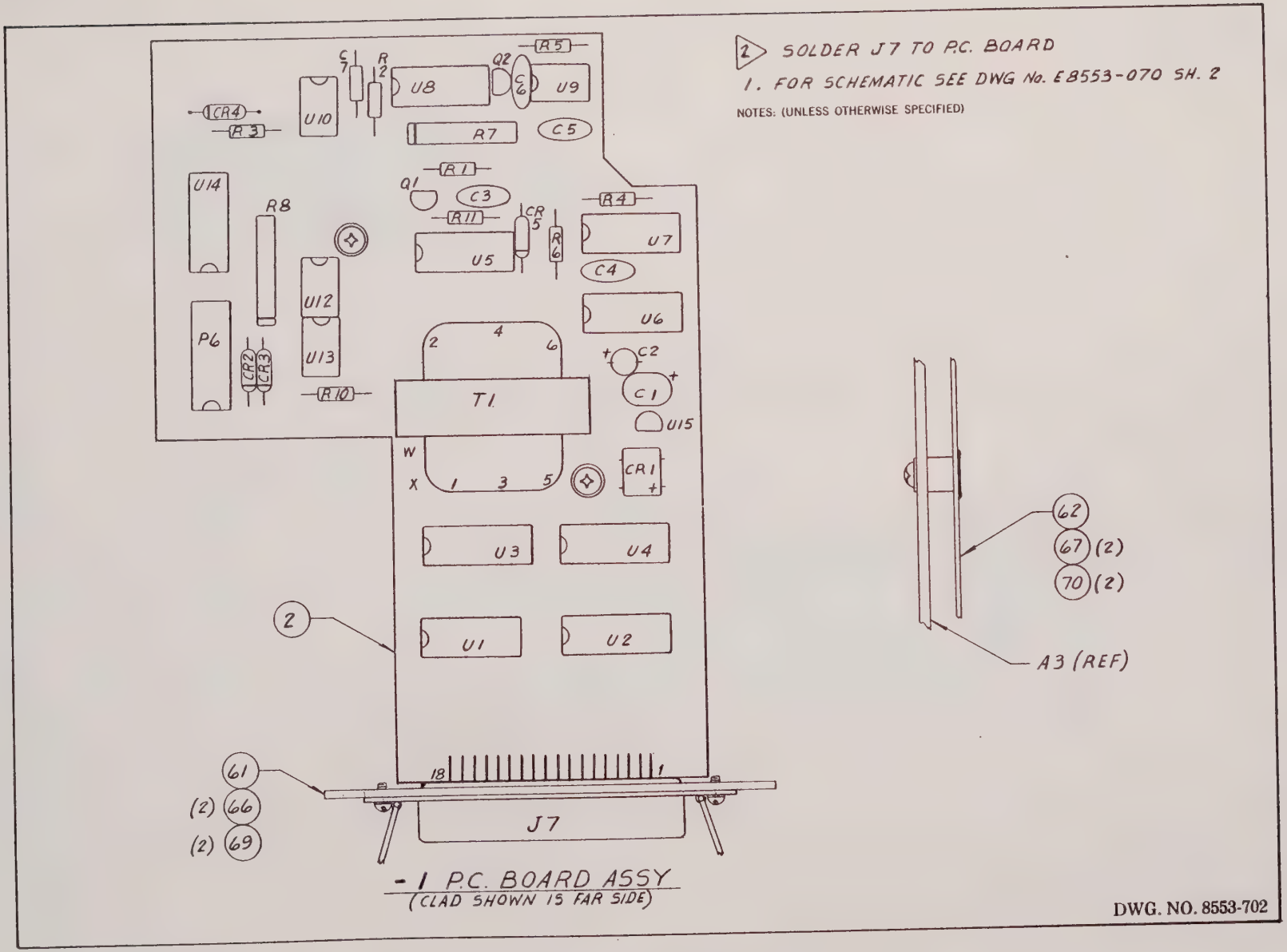


Figure 6-6. P.C. Board Assembly, Print Board (A3)

REPLACEABLE PARTS

7.1 GENERAL

This section contains ordering information and complete list of replaceable parts. Parts are listed by major assembly in alphanumerical order of their reference designators. Description, manufacturers' part number, manufacturers' code ident number (see Appendix A for list of manufacturers), and California Instruments' stock number are indicated.

7.2 ORDERING INFORMATION

In order to provide our customers with prompt service on replacement parts, please provide the following information, when applicable, for each part ordered:

a) Model number and serial number of the instrument.

b) California Instruments part number of the sub-assembly where component is located.

c) Component reference designator.

d) Component description.

e) Component manufacturer's number and code ident.

f) California Instruments stock number.

All replacement parts orders should be placed with California Instruments, Division of Amstar Technical Products Co., Inc., San Diego, California, 92111-1266.

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
	8553-400-1	UNIT ASSEMBLY	16067		1
	8553-400-2	UNIT ASSY W/PRINT BD.	16067	OPTION 02	2
	8553-400-3	4-WIRE CABLE SET	16067	OPTION 01	3
A1	8553-700-1	MAIN P.C. BD. ASSY	16067		4
A2	8553-701-1	DISPLAY BD. (INSTALLED ON MAIN BD.)			5
A3	8553-702-1	PRINT P.C. BD. ASSY	16067		6
					7
F1	313.125	FUSE 1/8A S.B.	75915	2-70043	8
					9
	2BC-AL-36	CABLE ASSEMBLY	05276	2-50152	10
					11
J1	1276-RED	BINDING POST	83330	2-50323	12
J2	1276-BLK	BINDING POST	83330	2-50322	13
J3	1276-RED	BINDING POST	83330	2-50323	14
J4	1276-BLK	BINDING POST	83330	2-50322	15
J5	1276-BLK	BINDING POST	83330	2-50322	16
					17
	P1 THRU P7 NOT USED IN THIS ASSY				18
P8	17237	POWER CORD	70903	2-50203	19
R15	RC07GF473J	RESISTOR 47K 1/4W 5%	81349	5-10092	20
XF1	345001	FUSE HOLDER	75915	2-40264	21
R1 THRU R14		NOT USED			22
					23
	8553-201-7	FRONT PANEL	16067	2-10632	24
	8553-202-7	REAR PANEL	16067	2-10633	25
	8553-202-8	REAR PANEL (W/PRT. BD.)	16067	2-10636	26
					27
	8553-208-7	CALIB. INSTRUCTION	16067	2-10639	28
					29
	C300-H-BLK *	PLASTIC ENCLOSURE	000AG	2-10634	30
*	ORDER WITH 31/4" LG. SCREWS INSTEAD OF THE 3"LG.				31
	PURCHASING: MODIFY TOP & BOTTOM COVER PER DWG. 8553-200				32
	4115	SHORTING STRAP	05276	2-50159	33
	8222-B-0632	SPACER 1 1/8 LG.	06540	2-10637	34
					35
					36

MODEL	DMM 53	CALICO P/N	8553-400	ASSY R.D.
TITLE	UNIT ASSEMBLY	SHT	3 OF 4	

Aiken Industries California Instruments Division | CODE IDENT 16067 | **PARTS LIST**

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
					37
					38
	SR-5L-1	STRAIN RELIEF	28520	2-10480	39
	2090	RUBBER FEET	08065	2-10547	40
	# 4 x 1/4 LG TYPE B	SELF TAPPING SCREW	45722	2-10638	41
					42
	283 1/2-WHT	2 COND. SHLD. /TEFL. INSUL.	92194		43
					44
					45
	6-32 X 5/16 LG.	SCREW PN. HD.	81349		46
	#6	WASHER INT. STR.	81349		47
	4-40 X 1/4 LG.	SCREW PN. HD.	81349		48
	#4	WASHER INT. STR.	81349		49
					50

MODEL	CALICO P/N	ASSY R.D.
DMM 53	8553-400	
TITLE	SHT 4 OF 4	
UNIT ASSEMBLY		

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1	8553-700-1	MAIN PC BOARD ASSY	16067		1
	8553-700-7	PC BOARD MECH	16067	1-60291	2
A2	8553-701-1	DISPLAY BOARD ASSY	16067		3
	EYELET	SEE SHEET 3 (S-6045)			4
					5
					6
A1C1	530-000	CAPACITOR, VAR. 25-1.5 PF	72982	6-11026	7
A1C2	160-.22-M-250F	CAPACITOR, .22μF 250V	000AD	6-11058	8
A1C3	T362B106M025AS	CAPACITOR 10μF 25V	05397	6-10738	9
A1C4	563-013	CAPACITOR VAR. .8-8.5PF	72982	6-10918	10
A1C5	CM06F152J03	CAPACITOR 1500 PF	81349	6-10302	11
A1C6	160-1.0-M-100H	CAPACITOR 1μF 100V	000AD	6-11059	12
A1C7	160-1.0-M-100H	CAPACITOR 1μF 100V	000AD	6-11059	13
A1C8	530-000	CAPACITOR VAR,. 25-1.5PF	72982	6-11026	14
A1C9	TDA2200M16T	CAPACITOR 2200μF 16V	30039	6-11056	15
A1C10	C22A102K	CAPACITOR 1000 PF 100V	71590	6-11060	16
A1C11	502D227G035DK1C	CAPACITOR 220μF 35V	56289	6-11057	17
A1C12	502D227G035DK1C	CAPACITOR 220μF 35V	56289	6-11057	18
A1C13	502D227G035DK1C	CAPACITOR 220μF 35V	56289	6-11057	19
A1C14	502D227G035DK1C	CAPACITOR 220μF 35V	56289	6-11057	20
A1C15	CM05F221J03	CAPACITOR 220PF 500V	81349	6-10036	21
A1C16	CK103	CAPACITOR .01μF 50V	71590	6-10094	22
A1C17	CM05F101J03	CAPACITOR 100PF 500V	81349	6-10027	23
A1C18	C22A102K	CAPACITOR 1000PF 100V	71590	6-11060	24
A1C19	MPP-1I-1.5-200-10	CAPACITOR 1.5μF 200V	000AE	6-11061	25
A1C20	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	26
A1C21	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	27
A1C22	160-1.0-M-100H	CAPACITOR 1μF 100V	000AD	6-11059	28
A1C23	CM05F221J03	CAPACITOR 220 PF 500V	81349	6-10036	29
A1C24	CM05F101J03	CAPACITOR 100PF 500V	81349	6-10027	30
A1C25	C22A102K	CAPACITOR 1000PF 100V	71590	6-11060	31
A1C26	CM05F101J03	CAPACITOR 100PF 500V	81349	6-10027	32
A1C27	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	33
A1C28	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	34
A1C29	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	35
A1C30	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	36

MODEL	DMM 53	CALICO P/N	8553-700	ASSY R.D.
TITLE	MAIN P.C. BOARD ASSY	SHT	4 OF 11	A1

Aiken Industries California Instruments Division | CODE IDENT 16067 | **PARTS LIST**

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1C31	CM05E300J03	CAPACITOR 30 PF 500V	81349	6-10263	37
A1C32	C22A102K	CAPACITOR 1000PF 100V	71590	6-11060	38
A1C33	CN0515	CAPACITOR 1.5pf 1KV	90201	6-11062	39
A1C34	160-.22-M-250F	CAPACITOR .22μF 250V	000A D	6-11058	40
A1C35	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	41
A1C36	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	42
A1C37	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	43
A1C38	C22A102K	CAPACITOR 1000PF 100V	71590	6-11060	44
A1C39	T362B475M025AS	CAPACITOR 4.7μF 25V	05397	6-10802	45
A1C40	CN0515	CAPACITOR 1.5PF 1KV	90201	6-11062	46
A1C41	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	47
A1C42	C22A102K	CAPACITOR 1000pf 100V	71590	6-11060	48
A1C43	TCA-104Z	CAPACITOR .1μF 25V	84171	6-11007	49
A1C44	C280AE/A100K	CAPACITOR .1μF 250V	73445	6-10916	50
A1C 45	C22A 102K	CAPACITOR 1000pf 100V	71590	6-11060	51
A 1CR 1	1N4148	DIODE	25403	3-10227	52
A 1CR 2	1N4148	DIODE	25403	3-10227	53
A 1CR 3	1N4004	DIODE	04713	3-10062	54
A 1CR 4	1N4004	DIODE	04713	3-10062	55
A 1CR 5	1N4004	DIODE	04713	3-10062	56
A 1CR6	1N4004	DIODE	04713	3-10062	57
A 1CR7	1N5251B	DIODE, ZENER	04713	3-10131	58
A 1CR8	VM28	RECTIFIER, BRIDGE	27683	3-10254	59
A1CR9	VM28	RECTIFIER, BRIDGE	27683	3-10254	60
A1CR10	1N5251B	DIODE, ZENER	04713	3-10131	61
A1CR11	1N5230B	DIODE, ZENER	04713	3-10175	62
A1CR12	1N4004	DIODE	04713	3-10062	63
A 1CR13	1N4004	DIODE	04713	3-10062	64
A1CR14	1N4148	DIODE	25403	3-10227	65
A1CR15	1N4004	DIODE	04713	3-10062	66
A1CR16	1N4004	DIODE	04713	3-10062	67
A1CR17	1N5230B	DIODE, ZENER	04713	3-10175	68
A1CR18	NOT USED				69
A1CR19	1N4148	DIODE	25403	3-10227	70
A1CR20	1N4148	DIODE	25403	3-10227	71
A1CR21	1N4148	DIODE	25403	3-10227	72

MODEL DMM 53 | CALICO P/N 8553-700 | ASSY R.D. A1

TITLE MAIN PC BOARD ASSY | SHT 5 OF 11

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
					73
					74
					75
					76
					77
A1J1 THRU A1J5 NOT USED					78
A1J6	CA-16S-TSD	SOCKET, 16 PIN	25072	2-30057	79
					80
					81
					82
					83
A1K1	CR-4003-6-1010	RELAY, 1 F.A.	71707	2-45158	84
A1K2	AZ-428-V10-40L	RELAY, 2 F.A.	26806	2-45129	85
A1K3	CR-4533	RELAY, 1 F.A.	71707	2-45150	86
A1K4	AZ-428-V10-40L	RELAY, 2 F.C.	26806	2-45129	87
A1K5	CR-4533	RELAY, 1 F.A	71707	2-45150	88
A1K6	CR-4533	RELAY, 1 F.A.	71707	2-45150	89
A1K7	CR-4533	RELAY, 1 F.A.	71707	2-45150	90
					91
					92
					93
A1Q1	PN2222A	TRANSISTOR,	07263	3-30284	94
A1Q2	PN2907A	TRANSISTOR	07263	3-30285	95
A1Q3	PN2222A	TRANSISTOR	07263	3-30284	96
A1Q4	PN2222A	TRANSISTOR	07263	3-30284	97
A1Q5	PN2222A	TRANSISTOR	07263	3-30284	98
A1Q6	PN2907A	TRANSISTOR	07263	3-30285	99
A1Q7	2N3685-T092	TRANSISTOR,	32293	3-30300	100
A1Q8	2N3685-T092	TRANSISTOR	32293	3-30300	101
A1Q9	2N3685-T092	TRANSISTOR,	32293	3-30300	102
A1Q10	2N3685-T092	TRANSISTOR	32293	3-30300	103
A1Q11	PN2222A	TRANSISTOR	07263	3-30284	104
A1Q12	PN2222A	TRANSISTOR	07263	3-30284	105
A1Q13	PN2222A	TRANSISTOR	07263	3-30284	106
A1Q14	PN2222A	TRANSISTOR,	07263	3-30284	107
A1Q15	PN2907A	TRANSISTOR	07263	3-30285	108

MODEL DMM 53	CALICO P/N 8553-700		ASSY R.D.
TITLE MAIN PC BOARD ASSY		SHT 6 OF 11	A1

Aiken Industries California Instruments Division | CODE IDENT 16067 | **PARTS LIST**

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1Q16	PN2907A	TRANSISTOR	07263	3-30285	109
A1Q17	MPS A14	TRANSISTOR	07263	3-30216	110
A1Q18	PN2222A	TRANSISTOR	07263	3-30284	111
A1Q19	PN2222A	TRANSISTOR	07263	3-30284	112
A1Q20	PN2222A	TRANSISTOR	07263	3-30284	113
A1Q21	PN2907A	TRANSISTOR	07263	3-30285	114
A1Q22	NOT USED				115
A1Q23	PN2907A	TRANSISTOR	07263	3-30285	116
A1Q24	PN2222A	TRANSISTOR	07263	3-30284	116
A1Q25	PN2222A	TRANSISTOR	07263	3-30284	117
A1Q26	PN2222A	TRANSISTOR	07263	3-30284	118
					119
					120
					121
					122
A1R1	120K-9-104	POTENTIOMETER 100K	71450	5-70254	123
A1R2	120K-9-104	POTENTIOMETER 100K	71450	5-70254	124
A1R3	63P253	POTENTIOMETER 25K	02111	5-70257	125
A1R4	RC07GF475J	RESISTOR 4.7M 1/4W 5%	81349	5-10130	126
A1R5	RC07GF205J	RESISTOR 2M 1/4W 5%	81349	5-10159	127
A1R6	63P201	POTENTIOMETER 200Ω	02111	5-70258	128
A1R7	NOT USED				129
A1R8	NOT USED				130
A1R9	RC07GF100J	RESISTOR 10Ω 1/4W 5%	81349	5-10005	131
A1R10	PME75T9	RESISTOR 2M . 1%	03888	5-80417	132
A1R11	63P200	POTENTIOMETER 20Ω	02111	5-70259	133
A1R12	RN55D4423F	RESISTOR 442K 1%	81349	5-60745	134
A1R13	RC42GF104J	RESISTOR 100K 2W 5%	81349	5-40015	135
A1R14	63P104	POTENTIOMETER 100K	81349	5-70265	136
A1R15	NOT USED				137
A1R16	RN55E1913B	RESISTOR 191K . 1%	81349	5-60735	138
A1R17	63P 502	POTENTIOMETER 5K	02111	5-70260	139
A1R18	RN55E1551B	RESISTOR 1.55K . 1%	81349	5-60746	140
A1R19	RN55E1503B	RESISTOR 150K . 1%	81349	5-60737	141
A1R20	RN55D1003F	RESISTOR 100K 1%	81349	5-60573	142
A1R21	63P101	POTENTIOMETER 100Ω	02111	5-70262	143

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TITLE MAIN PC BOARD ASSY | SHT 7 OF 11

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R22	RC07GF151J	RESISTOR 150Ω 1/4W 5%	81349	5-10033	144
A1R23	RC07GF100J	RESISTOR 10Ω 1/4W 5%	81349	5-10005	145
A1R24	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	146
A1R25	RC07GF151J	RESISTOR 150Ω 1/4W 5%	81349	5-10033	147
A1R26	699-1-100K-D	RESISTOR ARRAY 100K . 1%	73138	3-60204	148
A1R27	63P102	POTENTIOMETER 1K	02111	5-70261	149
A1R28	63P101	POTENTIOMETER 100Ω	02111	5-70262	150
A1R29	63P100	POTENTIOMETER 10Ω	02111	5-70263	151
A1R30	RC07GF510J	RESISTOR 51Ω 1/4W 5%	81349	5-10022	152
A1R31	RC07GF510J	RESISTOR 51Ω 1/4W 5%	81349	5-10022	153
A1R32	699-1-2K-D	RESISTOR ARRAY 2K	73138	3-60205	154
A1R33	63P202	POTENTIOMETER 2K	02111	5-70264	155
A1R34	RN55E6652B	RESISTOR 66.5K . 1%	81349	5-60739	156
A1R35	RN55E6652B	RESISTOR 66.5K . 1%	81349	5-60739	157
A1R36	AE-100-268	RESISTOR, NETWORK	00730	5-80415	158
A1R37	RC07GF105J	RESISTOR, 1M, , 1/4W, 5%	81349	5-10123	159
A1R38	RN55D29R4F	RESISTOR, 29.4Ω 1%	81349	5-60740	160
A1R39	RC07GF104J	RESISTOR, 100K 1/4W 5%	81349	5-10100	161
A1R40	764-3-R100K	RESISTOR, SIP 100K	73138	3-60206	162
A1R41	764-3-R10K	RESISTOR, SIP 10K	73138	3-60207	163
A1R42	63P101	POTENTIOMETER 100Ω	02111	5-70262	164
A1R43	63P104	POTENTIOMETER 100K	02111	5-70265	165
A1R44	RC07GF202J	RESISTOR 2K 1/4W 5%	81349	5-10059	166
A1R45	RC42GF203J	RESISTOR 20K 2W 5%	81349	5-40022	167
A1R46	RC07GF203J	RESISTOR 20K 1/4W 5%	81349	5-10083	168
A1R47	63P104	POTENTIOMETER 100K	02111	5-70265	169
A1R48	63P104	POTENTIOMETER 100K	02111	5-70265	170
A1R49	RN55D10R0F	RESISTOR 10Ω 1%	81349	5-60728	171
A1R50	KB21J1	THERMISTOR	15801	2-50324	172
A1R51	699-1-100K-D	RESISTOR ARRAY 100K . 1%	73138	3-60204	173
A1R52	63P201	POTENTIOMETER 200Ω	02111	5-70258	174
A1R53	RC07GF106J	RESISTOR 10M 1/4W 5%	81349	5-10135	175
A1R54	699-1-100K-D	RESISTOR ARRAY 100K . 1%	73138	3-60204	176
A1R55	63P202	POTENTIOMETER 2K	02111	5-70264	177
A1R56	764-3-R100K	RESISTOR, SIP 100K	73138	3-60206	178
A1R57	63P253	POTENTIOMETER 25K	02111	5-70257	179

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TITLE	MAIN PC BOARD ASSY	SHT	8 OF 11	A1

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REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R58	63P253	POTENTIOMETER 25K	02111	5-70257	180
A1R59	CC3574F	RESISTOR 3.57M 1%	01121	5-60743	181
A1R60	RN55C2001F	RESISTOR 2K 1%	81349	5-60742	182
A1R61	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	183
A1R62	RC07GF474J	RESISTOR 470K 1/4W 5%	81349	5-10115	184
A1R63	764-3-R10K	RESISTOR, SIP 10K	73138	3-60207	185
A1R64	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	186
A1R65	RC07GF105J	RESISTOR 1M 1/4W 5%	81349	5-10123	187
A1R66	RC07GF104J	RESISTOR 100K 1/4W 5%	81349	5-10100	188
A1R67	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10076	189
A1R68	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	190
A1R69	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10076	191
A1R70	RC07GF202J	RESISTOR 2K 1/4W 5%	81349	5-10059	192
A1R71	RC07GF202J	RESISTOR 2 K 1/4W 5%	81349	5-10059	193
A1R72	898-3-R10K	RESISTOR, ARRAY 10K	73138	3-60208	194
A1R73	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	195
A1R74	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	196
A1R75	RC07GF226J	RESISTOR 22M 1/4W 5%	81349	5-10139	197
A1R76	RC07GF104J	RESISTOR 100K 1/4W 5%	81349	5-10100	198
A1R77	RN55E1503B	RESISTOR 150K .1%	81349	5-60737	199
A1R78	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10076	200
A1R79	RC07GF203J	RESISTOR 20K 1/4W 5%	81349	5-10083	201
A1R80	RC07GF100J	RESISTOR 10Ω 1/4W 5%	81349	5-10005	202
A1R81	RC07GF104J	RESISTOR 100K 1/4W 5%	81349	5-10100	203
A1R82	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	204
A1R83	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10076	205
A1R84	RC07GF103J	RESISTOR 10K 1/4W 5%	81349	5-10076	206
A1R85	RC07GF474J	RESISTOR 470K 1/4W 5%	81349	5-10115	207
A1R86	RC07GF224	RESISTOR 220K 1/4W 5%	81349	5-10108	208
A1R87	RC07GF472J	RESISTOR 4.7K 5% 1/4W	81349	5-10068	209
A1R88	RC07GF473J	RESISTOR 47K 1/4W 5%	81349	5-10092	210
A1R89	NOT USED				211
A1R90	RC07GF393J	RESISTOR 39K 1/4W 5%	81349	5-10090	212
A1R91	RC07GF203J	RESISTOR 20K 1/4W 5%	81349	5-10083	213
A1R92	RC07GF101J	RESISTOR 100Ω 1/4W 5%	81349	5-10029	214
A1R93	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	215

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TITLE MAIN PC BOARD ASSY | SHT 9 OF 11

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1R94	RC07GF106J	RESISTOR 10M 1/4W 5%	81349	5-10135	216
					217
A1S1	8553-011	SWITCH, PUSH BUT.	16067	2-40476	218
A1S2	46206LF	SWITCH, 115-230V	82389	2-40298	219
					220
A1T1	8553-010	TRANSFORMER, POWER	16067	7-10317	221
					222
					223
					224
A1U1	TL072CP	INTEGRATED CIRCUIT	01295	3-60213	225
A1U2	LH0070-2	REFERENCE, VOLTAGE	27014	3-60214	226
A1U3	OP12FT	INTEGRATED CIRCUIT	06665	3-60215	227
A1U4	UA78M05UC	INTEGRATED CIRCUIT	07263	3-60216	228
A1U5	LF356N	INTEGRATED CIRCUIT	27014	3-60217	229
A1U6	1T401AJE	FET ARRAY	32293	3-60220	230
A1U7	MC78L18ACP	REGULATOR, VOLTAGE	04713	3-60221	231
A1U8	MC79L18ACP	REGULATOR, VOLTAGE	04713	3-60222	231
A1U9	1T401AJE	FET ARRAY	32293	3-60220	232
A1U10	LF356N	INTEGRATED CIRCUIT	27014	3-60217	233
A1U11	LF356N	INTEGRATED CIRCUIT	27014	3-60217	234
A1U12	CA3141E	DIODE ARRAY	95303	3-60223	235
A1U13	LF356N	INTEGRATED CIRCUIT	27014	3-60217	236
A1U14	LM339N	INTEGRATED CIRCUIT	27014	3-60218	237
A1U15	LM393N	INTEGRATED CIRCUIT	27014	3-60219	238
A1U16	SN74LS175N	INTEGRATED CIRCUIT	07263	3-60150	239
A1U17	SN74LS153N	INTEGRATED CIRCUIT	07263	3-60224	240
A1U18	SN7400N	INTEGRATED CIRCUIT	81349	3-60000	241
A1U19	SN74LS08N	INTEGRATED CIRCUIT	07263	3-60183	242
A1U20	SN74LS86N	INTEGRATED CIRCUIT	07263	3-60147	243
A1U21	SN74LS74N	INTEGRATED CIRCUIT	07263	3-60161	244
A1U22	SN74LS74N	INTEGRATED CIRCUIT	07263	3-60161	245
A1U23	8553-012	INTEGRATED CIRCUIT	16067	3-60225	246
A1U24	SN74LS192N	INTEGRATED CIRCUIT	07263	3-60148	247
A1U25	SN74LS00N	INTEGRATED CIRCUIT	07263	3-60156	248
A1U26	SN74LS04N	INTEGRATED CIRCUIT	07263	3-60159	249
A1U27	SN74LS04N	INTEGRATED CIRCUIT	07263	3-60159	250

MODEL	DMM 5.3	CALICO P/N	8553-700	ASSY R.D.
TITLE	MAIN PC BOARD ASSY	SHT	10 OF	A1

Aiken Industries California Instruments Division | CODE IDENT 16067 | **PARTS LIST**

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A1U28	SN74LS74N	INTEGRATED CIRCUIT	07263	3-60161	251
					252
					253
					254
					255
A1Y1	HC6/U-2MHz	CRYSTAL, 2MHz±.005%	000AF	2-50320	256
					257
	2010B-1	TERMINAL NON-INS.	88245	2-50076	258
	FSN-23A-14	FLEX-STRIP	15912	2-50321	259
	ICN-083-S3-T	8 PIN DIP SOCKETS	06776	3-60230	260
					261
					262
	RCT05075-7A	TRANSISTOR PAD	19080	2-40296	263
					264
					265
					266
	4-40 X 3/8 LG	SCREW, PAN HD	81349		267
	#4	WASHER, INT. STR.	81349		268
	#4-40	HEX NUT	81349		269
					270
					271
					272
	#8	LOCK WASHER	81349		272
	#8-32	HEX NUT	81349		273
					274
					275
	2-56 x 1/4 LG	SCREW PAN HD.	81349		276
	#2	WASHER, SPLIT LOCK	81349		277
	#2-56	HEX NUT	81349		278
					279
	1/4" Dia.	RED PRESS DOT	81349		280
					281
	26 GA .015 DIA	PIANO WIRE TIN PLATED	81349		282
					283
					284
					285

MODEL DMM 53 | CALICO P/N 8553-700 | ASSY R.D.

TITLE MAIN P.C. BOARD ASSY | SHT 11 OF 11 | A1

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REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A2	8553-701-1	P.C. BOARD ASSY	16067	DMM 53	1
		. . .			2
	8553-701-7	P.C. BOARD MECH.	16067	1-60292	3
					4
					5
					6
A2C1	CM05F221J03	CAPACITOR 220PF 500V	81349	6-10036	7
A2C2	C22A102K	CAPACITOR 1000 PF 100V	71590	6-11060	8
A2C3	T362B336M010AS	CAPACITOR 33μF 10V	05397	6-10751	9
A2C4	T362B336M010AS	CAPACITOR 33μF 10V	05397	6-10751	10
					11
					12
					13
					14
A2CR1	1N4148	DIODE	25403	3-10227	15
					16
					17
					18
					19
A2DS1	FND 508-7 OR 8	DISPLAY, POLARITY	000AC	2-30072	20
A2DS2	FND 507-7 OR 8	DISPLAY, NUMERICAL	000AC	2-30073	21
A2DS3	FND 507-7 OR 8	DISPLAY, NUMERICAL	000AC	2-30073	22
A2DS4	FND 507-7 OR 8	DISPLAY, NUMERICAL	000AC	2-30073	23
A2DS5	FND 507-7 OR 8	DISPLAY, NUMERICAL	000AC	2-30073	24
A2DS6	FND 507-7 OR 8	DISPLAY, NUMERICAL	000AC	2-30073	25
A2DS7	LSL-3L	L.E.D.	0000S	2-50212	26
		. . .			27
		. . .			28
					29
					30
					31
A2Q1	PN2222A	TRANSISTOR	07263	3-30284	32
A2Q2	MPS-A14	TRANSISTOR	04713	3-30216	33
A2Q3	MPS-A14	TRANSISTOR	04713	3-30216	34
A2Q4	MPS-A14	TRANSISTOR	04713	3-30216	35
A2Q5	MPS-A14	TRANSISTOR	04713	3-30216	36

MODEL	CALICO P/N	ASSY R.D.
DMM 53	8553-701	
TITLE	SHT 4 OF 5	
DISPLAY BOARD ASSY		A2

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A2Q6	PN2222A	TRANSISTOR	07263	3-30284	37
					38
					39
					40
A2R1	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	41
A2R2	785-3-R100Ω	RESISTOR SIP, 100Ω	73138	3-60209	42
A2R3	RC07GF101J	RESISTOR 100Ω 1/4W5%	81349	5-10029	43
A2R4	RC07GF334J	RESISTOR 330K 1/4W 5%	81349	5-10112	44
A2R5	785-3-R22 Ω	RESISTOR SIP, 22 Ω	73138	3-60210	45
A2R6	785-3-R22-Ω	RESISTOR SIP, 22Ω	73138	3-60210	46
A2R7	RC07GF221J	RESISTOR 220Ω 1/4W 5%	81349	5-10037	47
A2R8	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	48
A2R9	RC07GF100J	RESISTOR 10Ω 1/4W 5%	81349	5-10005	49
A2R10	RC07GF4R7J	RESISTOR 4.7Ω 1/4W 5%	81349	5-10002	50
A2R11	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	51
					52
					53
					54
					55
A2U1	9374	INTEGRATED CIRCUIT	07263	3-60229	56
A2U2	SN74247N	INTEGRATED CIRCUIT	07263	3-60227	57
A2U3	HCTR6010A	INTEGRATED CIRCUIT	27832	3-60228	58
A2U4	SN74LS390N	INTEGRATED CIRCUIT	01295	3-60226	59
					60
					61
					62
					63
					64
					65
					66
					67
					68
					69
					70
					71
					72

MODEL DMM 53	CALICO P/N 8553-701	ASSY R.D.
TITLE DISPLAY BOARD ASSY	SHT 5 OF 5	A2

Aiken Industries	California Instruments Division	CODE IDENT 16067	PARTS LIST

REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A3	8553-702-1	P.C. BOARD ASSEMBLY	16067		1
	8553-702-7	P.C. BOARD MECH.	16067	1-60293	2
	SEE SHT. 3	EYELET			3
					4
A3C1	503D687G016EK	CAPACITOR 680µF 16V	56289	6-11055	5
A3C2	TCA-104Z	CAPACITOR .1µF 25V	84171	6-11007	6
A3C3	TCA-104Z	CAPACITOR .1µF 25V	84171	6-11007	7
A3C4	TCA-104Z	CAPACITOR .1µF 25V	84171	6-11007	8
A3C5	CK-10371590	CAPACITOR .01µF 50V	71590	6-10094	9
A3C6	5C023105X0250B3	CAPACITOR .1µF 25V	56289	6-10440	10
A3C7	C22A102K	CAPACITOR 1000 pF 100V	71590	6-11060	11
					12
					13
A3CR1	VM28	DIODE, BRIDGE	27683	3-10254	14
A3CR2	1N270	DIODE	81349	3-10006	15
A3CR3	1N270	DIODE	81349	3-10006	16
A3CR4	1N270	DIODE	81349	3-10006	17
A3CR5	1N270	DIODE	81349	3-10006	18
					19
					20
A3J1 THRU A3J6 NOT USED IN THIS ASSY					21
A3J7	57-40360	CONNECTOR (36 PIN)	02660	4-10208	22
					23
A3P1 THRU A3P5 NOT USED IN THIS ASSY					24
A3P6	5142-009	CONNECTOR CABLE ASSY	08261	4-10243	25
					26
A3Q1	PN2222A	TRANSISTOR	81349	3-30284	27
A3Q2	PN2907A	TRANSISTOR	02763	3-30285	28
					29
A3R1	RC07GF223J	RESISTOR 22K 1/4W 5%	81349	5-10084	30
A3R2	RC07GF472J	RESISTOR 4.7K 1/4W 5%	81349	5-10068	31
A3R3	RC07GF101J	RESISTOR 100Ω 1/4W 5%	81349	5-10029	32
A3R4	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	33
A3R5	RC07GF105J	RESISTOR 1M 1/4W 5%	81349	5-10123	34
A3R6	RC07GF223J	RESISTOR 22K 1/4W 5%	81349	5-10084	35
A3R7	764-1-R22K	RESISTOR SIP 22K	73138	3-60154	36

MODEL	DMM 53	CALICO P/N	8553-702		ASSY R.D.
TITLE	PRINT BOARD ASSEMBLY			SHT 4 OF 5	A3

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REF. DES.	MFG. NUMBER	DESCRIPTION	CODE IDENT	CALICO STOCK NUMBER	ITEM NO.
A3R8	764-3-R220Ω	RESISTOR SIP 220Ω	73138	3-60212	37
A3R9	NOT USED				38
A3R10	RC07GF102J	RESISTOR 1K 1/4W 5%	81349	5-10053	39
A3R11	RC07GF223J	RESISTOR 22K 1/4W 5%	81349	5-10084	40
					41
					42
A3T1	F-131P	TRANSFORMER	81095	7-10316	43
					44
					45
A3U1	SN74LS08N	INTEGRATED CIRCUIT	07263	3-60183	46
A3U2	SN74LS390N	INTEGRATED CIRCUIT	01295	3-60226	47
A3U3	SN74LS390N	INTEGRATED CIRCUIT	01295	3-60226	48
A3U4	SN74LS390N	INTEGRATED CIRCUIT	01295	3-60226	49
A3U5	SN74LS74N	INTEGRATED CIRCUIT	07263	3-60161	50
A3U6	SN74LS04N	INTEGRATED CIRCUIT	07263	3-60159	51
A3U7	SN74LS86N	INTEGRATED CIRCUIT	07263	3-60147	52
A3U8	SN74LS03N	INTEGRATED CIRCUIT	07263	3-60158	53
A3U9	NE555V	INTEGRATED CIRCUIT	18324	3-60026	54
A3U10	5082-4350	PHOTO ISOLATOR	28480	3-60073	55
A3U11	NOT USED				56
A3U12	MCT 6	DUAL PHOTO ISOLATOR	50522	2-50325	57
A3U13	MCT 6	DUAL PHOTO ISOLATOR	50522	2-50325	58
A3U14	SN74LS05N	INTEGRATED CIRCUIT	07263	3-60160	59
A3U15	μA78L05/AWC	VOLTAGE REGULATOR	02335	3-60164	60
					61
					62
					63
	8553-204-7	MOUNTING PLATE CONN	16067	1-10649	64
	8553-205-7	SHIELD	16067	1-10650	65
					66
					67
	3-48 X 1/4 LG	SCREW ROUND HD.	81349	2-10631	68
	6-32 X 1/4 LG	SCREW PAN HD.	81349		69
					70
	#3	WASHER INT. STR.	81349	2-10584	71
	#6	WASHER INT. STR.	81349		72

MODEL DMM 53 | CALICO P/N 8553-702 | ASSY R.D.

TITLE PRINT BOARD ASSEMBLY | SHT 5 OF 5 | A3

Appendix A

Code	Name	City	State
0000A	Electricord	Westfield	PA
0000C	Jackson Bros.	Waddon, Surrey	GB
0000S	OPCDA	Edison	NJ
0000W	Milton Ross Co.	Southampton	PA
0000Z	Timco	Los Angeles	CA
000AC	ITAC	Santa Clara	CA
000AD	Plessey	Westlake Village	CA
000AG	La France	Philadelphia	PA
000AH	Jan Crystal	Ft. Myers	CA
000AL	Data Components, Inc.	Santa Monica	CA
000AM	Kraus & Naimer	Santa Monica	CA
000AN	Ritz Instrument Transformer Co.	Redondo Beach	CA
000AS	Switches Incorporated	Mt. View	CA
00544	Metal-Cal Div., Avery Prod. Corp.	Inglewood	CA
00779	AMP Inc.	Harrisburg	PA
00853	Sangamo Electric Co.	Pickens	SC
00866	Goe Eng. Co., Inc.	City of Industry	CA
01002	G.E. Co., Ind. & Pwr. Cap. Dept.	John St. Hudson Falls	NY
01121	Allen-Bradley Co.	Milwaukee	WI
01139	G.E. Co., Silicone Products Dept.	Waterford	NY
01295	Texas Instruments	Dallas	TX
02111	Spectrol Electronics	City of Industry	CA
02335	Fairchild Controls Corp.	Hicksville, LI	NY
02375	American Insulating Machinery Co.	Philadelphia	PA
02538	Texas Electronics Co.	Dallas	TX
02660	Amphenol Corporation	Broadview	IL
02799	Use Code #72136		
03507	General Electric Company	Syracuse	NY
03508	General Electric Company	Syracuse	NY
03797	Eldema Corporation	Compton	CA
03888	Pyrofilm Resistor Co., Inc.	Cedar Knolls	NJ
03911	Clairex Corporation	New York	NY
04009	Arrow-Hart and Hegeman Elec. Co.	Hartford	CT
04713	Motorola Semiconductor Prod., Inc.	Phoenix	AZ
04963	3-M	St. Paul	MN
05245	Corcom Inc.	Chicago	IL
05276	Pomona Electronics Co., Inc.	Pomona	CA
05397	Kemet, Union Carbide Corp.	Cleveland	OH
05820	Wakefield Engineering, Inc.	Wakefield	MA
06383	Panduit Corp.	Tinley Park	IL
06514	Stantron, Wyco Metal Products	N. Hollywood	CA
06540	Amathom Elect. Hardware	New Rochelle	NY
06665	Precision Monolithics Inc.	Santa Clara	CA
06776	Robinson Nugent, Inc.	New Albany	IN
06915	Richco Plastics, Co.	Chicago	IL
07088	Kelvin Electric Company	Van Nuys	CA
07263	Fairchild Camera and Instr. Corp.	Mt. View	CA
07387	Birtcher Corporation	Los Angeles	CA
07556	Unitrack Calabro Plastics	Upper Darby	PA
07633	Epoxy Prod. Co., Allied Prod. Corp.	New Haven	CT
07716	IRC Incorporated	Burrington	IA
08065	Accurate Rubber and Plastics Co.	San Diego	CA
08261	Spectra Strip	Garden Grove	CA
08289	Blinn-Delbert Co., Inc.	Pomona	CA
08353	Bristol Co.	Toronto	CANADA
08524	Deutsch Fastener Corp.	Los Angeles	CA
08730	Vemaline Products Co.	Franklin Lakes	NJ
08779	Signal Transformer Co.	Brooklyn	NY
09353	C and K Components	Newton	MA
10389	Chicago Switch Inc.	Chicago	IL
11815	Cherry Rivet Div., Townsend Co.	Santa Ana	CA
12406	Elpac, Incorporated	Fullerton	CA
12697	Clarostat Mfg. Co., Incorporated	Dover	NH
13103	Thermalloy Company	Dallas	TX
14099	Semtech Corporation	Newbury Park	CA
14604	Elmwood Sensors Inc.	Cranston	RI
14655	Cornell-Dubilier Elect. Corp.	Newark	NJ
14726	Hollingsworth Co.	Phoenixville	PA
14752	Electro Cube, Incorporated	San Gabriel	CA
15238	ITT Semiconductors	Lawrence	MA
15636	Elec-trol	Northridge	CA
15801	Fenwall Electronics	Framingham	MA
15818	Amelco Teledyne, Incorporated	Mt. View	CA
15912	Ansley	Los Angeles	CA
16067	California Instruments Company	San Diego	CA
16758	Delco Radio Div., General Motors	Kokomo	IN
16956	Dennison	Framingham	MS
18076	Umpco	City of Industry	CA
18178	Vactec, Inc.	Maryland Heights	Mo
18324	Signetics	Sunnyvale	CA
18612	Vishay Instruments Inc.	Malvern	PA
18677	Scambe Mfg. Co.	Monterey Park	CA
18722	RCA	Mountaintop	PA
18736	Voltronics Corp.	Hanover	NJ
19080	The Robinson Company	Hawthorne	CA
21604	Buckeye Stamping Company	Columbus	OH
22599	Elastic Stop Nut Corporation	Van Nuys	CA
23050	Product Components Corp.	Hastings-on-Hudson	NY
23936	Pamotor, Incorporated	San Francisco	CA
24011	ECC	Burlington	MA
24444	General Semiconductor Industries Inc.	Tempe	AZ
24796	Parelco Inc.	Paramount	CA
25497	Meter Master	Los Angeles	CA
26806	American Zettler, Inc.	Costa Mesa	CA
27014	National Semi-Conductor Corp.	Santa Clara	CA
27191	Cutler-Hammer, Inc.	Milwaukee	WI
27264	Molex	Downers Grove	IL
27556	IMB Electronic Products	Santa Fe Springs	CA
27683	Varo, Incorporated	St. Garland	TX
27832	Hughes Aircraft	Newport Beach	CA

Code	Name	City	State
28480	Hewlett-Packard Co.	Palo Alto	CA
28520	Heyman Mfg. Company (Heyco)	Kenilworth	NJ
30039	International Components Corp.	Asbury Park	NJ
30983	Electra/Midland (Mepco/Electra)	San Diego	CA
30161	Aavid Engineering Inc.	Laconia	NH
30897	Dorann Company	Sylmar	CA
31951	Triridge Inc.	Pittsburgh	PA
32293	Intersil	Cupertino	CA
32559	Bivar, Inc.	Santa Ana	CA
33005	Jewell Electrical Instruments Inc.	Manchester	NH
33716	Kingsbacher Murray Co.	Los Angeles	CA
33855	Ducommun Inc.	Los Angeles	CA
34333	Silicon General	Westminster	CA
34649	Intel Corporation	Santa Clara	CA
44655	Ohmite Manufacturing Company	Skokie	IL
45722	Parker-Kalon	Clifton	NJ
46384	Penn. Eng. and Mfg. Corp.	Doylestown	PA
50522	Monsanto, Electronic Special Products	Cupertino	CA
51167	Aries Electronics Inc.	Frenchtown	NJ
51705	ICO/Rally	Palo Alto	CA
52072	Circuit Assembly Corp.	Costa Mesa	CA
54407	Power-One Co.	Camarillo	CA
56289	Sprague Electric Company	North Adams	MA
58474	Superior Electric Company	Bristol	CT
59730	Thomas and Betts Company	Elizabeth	NJ
63743	Ward Leonard Electric Co.	Mt. Vernon	NY
70318	Allmetal Screw Prod. Co.	Garden City	NY
70903	Belden Manufacturing Co.	Chicago	IL
71218	Bud Industries, Inc.	Willoughby	OH
71279	Cambridge Thermionic Corp.	Cambridge	MA
71400	Bussman Mfg. Div. McGraw-Edison Co.	St. Louis	MO
71450	CTS Corporation	Elkhart	IN
71468	ITT Cannon Electric Inc.	Los Angeles	CA
71590	Centralab Div. Globe-Union, Inc.	Milwaukee	WI
71707	Coto-Coil	Providence	RI
71744	Chicago Miniature Lampworks	Chicago	IL
71785	TRW Cinch	Chicago	IL
71984	Dow Corning Corp.	Midland	MI
72136	Elmenco (Electro Motive)	Willimantic	CT
72619	Dialight Corporation	Brooklyn	NY
72699	General Instruments	Newark	NJ
72982	Erie Technological Products Inc.	Erie	PA
73138	Beckman Instruments, Inc.	Fullerton	CA
73734	Federal Screw Products, Inc.	Chicago	IL
74193	Heinemann Electric Company	Trenton	NJ
74545	Harvey Hubbell, Inc.	Bridgeport	CT
74840	Illinois Condenser Co.	Chicago	IL
74970	E.F. Johnson Company	Waseca	MN
75042	TRW Electronic Components	Philadelphia	PA
75382	Kulka Electric Corporaion	Mt. Vernon	NY
75915	Littlefuse Incorporated	Des Plaines	IL
77132	United-Carr Inc., Patwin Division	Waterbury	CT
77342	Potter and Brumfield Div., AMF	E. Princeton	IN
78189	Shakeproof Div., Illinois Tool Works	Chicago	IL
78553	Tinnerman Products, Inc.	Cleveland	OH
79130	Johns-Manville Products Corp.	Chicago	IL
79136	Waldes Kohinoor Inc.	Long Island City	NY
79963	Zierick Mfg. Corporation	New Rochelle	NY
80031	Mepco/Electra	Morristown	NJ
80223	United Transformer Co.	New York	NY
80294	Bourns, Incorporated	Riverside	CA
81095	Triad Transformer Corp.	Venice	CA
81312	Winchester Electronics	Oakville	CT
81349	Military Specification or Commercial Generic Number		
81603	Raco Products Co.	Chicago	IL
82104	Standard Grigsby	Aurora	IL
82389	Switchcraft, Incorporated	Chicago	IL
82877	Rotron Manufacturing Co., Inc.	Woodstock	NY
82893	Vector Electronics Inc.	Sylmar	CA
83330	Herman H. Smith, Inc.	Brooklyn	NY
83486	Elco Tool and Screw Corp.	Rockford	IL
86684	RCA	Harrison	NJ
87034	Marco-Oak Industries	Anaheim	CA
88245	Useco Div., Litton Industries	Van Nuys	CA
90201	Mallory Capacitor Company	Indianapolis	IN
91637	Dale Electronics, Inc.	Columbus	NE
91662	Elco Corporation	Willow Grove	PA
91833	Keystone Electronics Corp.	New York	NY
92194	Alpha Wire Corporation	Elizabeth	NJ
94222	Southco, Incorporated	Lester	PA
95303	RCA	Cincinnati	OH
95987	Weckesser Company, Inc.	Chicago	IL
97525	Electronic Engineering Co.	Santa Ana	CA
98159	Rubber Teck, Incorporated	Gardena	CA
98291	Sealecto Corp.	Mamaroneck	NY
98376	Zero Mfg. Co. (West)	Burbank	CA
98978	IERC	Burbank	CA
99743	IMC	Maywood	CA
99800	Delevan Electronics Corporation	Aurora	NY

Revision J
January 5, 1982

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS, Division of Amstar Technical Products Co., Inc., warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, and including the model number and serial number. On receipt of this information, service data or a Return Material Authorization (RMA) number will be given. Fill in RMA No. blank on shipping label attached opposite these instructions, pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No., or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS, San Diego, CA. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost, and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

From

California Instruments

A Division of Amstar Technical Products Company, Inc.

5150 Convoy Street
San Diego, California 92111

Attn: Customer Service

RMA NO. _____

MP MASTER
MA28086